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1904, Ap. - Aug.

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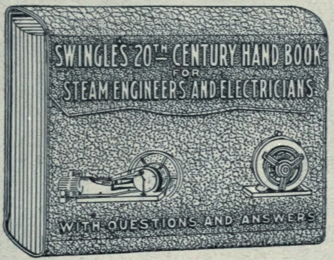
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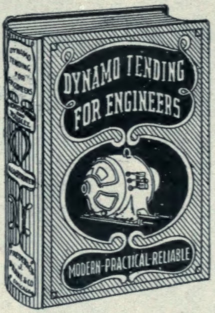

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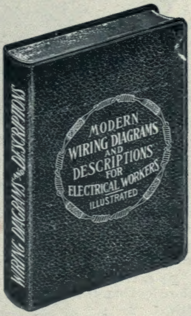
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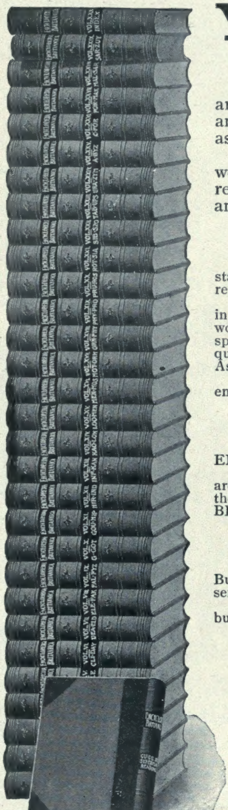

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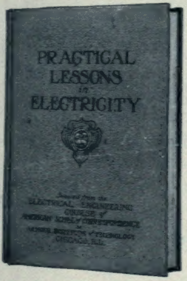

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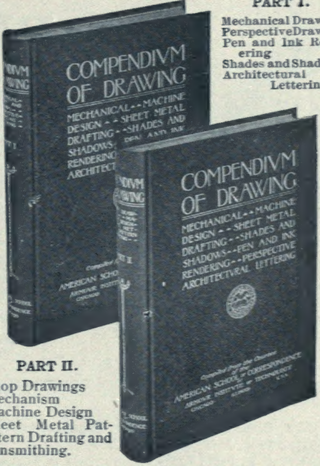
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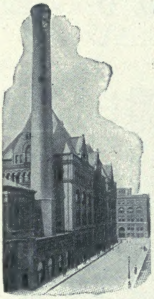

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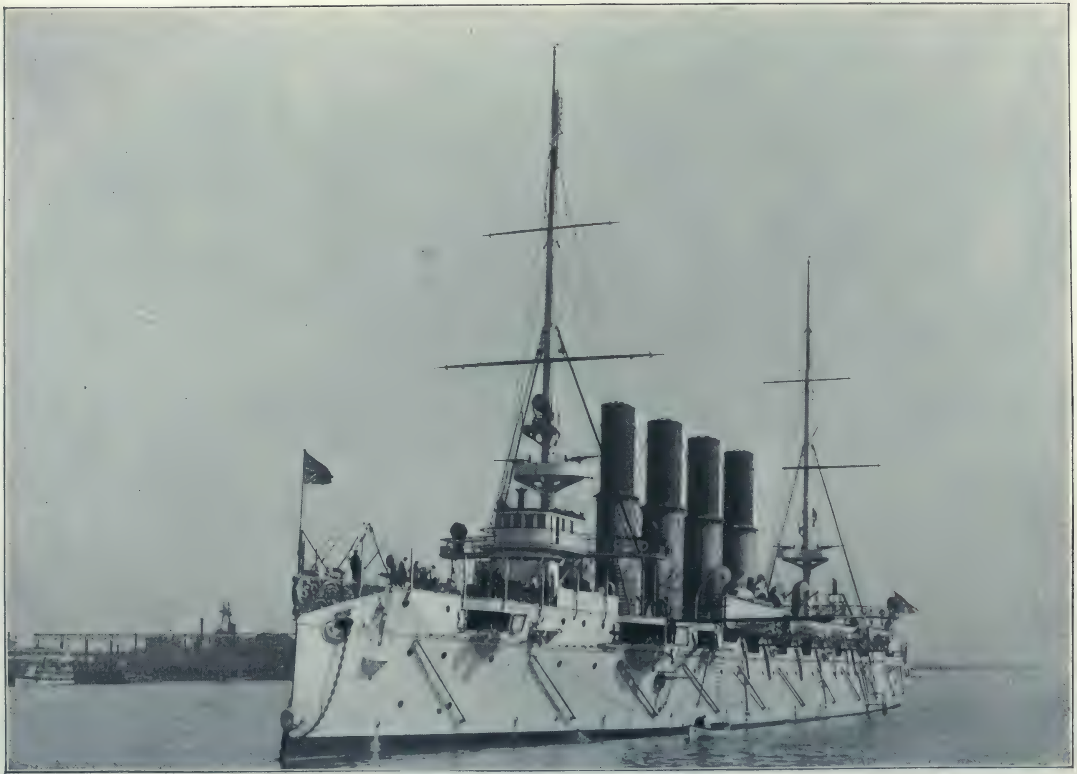

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Sunk, with companion cruiser *Korietz*, in the harbor of Chemulpo, Korea, February 9, 1904, after running fight with superior Japanese force of five cruisers and torpedo-boats. The *Variag* was an American-built vessel of 6,500 tons' displacement, built at the yards of Wm. Cramp & Sons, Philadelphia, Pa. On trial trip off Massachusetts coast in 1899, she developed a speed of 22 knots.

The

Technical World

Volume I *APRIL, 1904* *No. 2*

THE PROBLEM OF THE SUBMARINE

By Robert G. Skerrett

Submarine Expert

Formerly of the Navy Department, Washington, D. C.

THERE is a mysticism about the submarine torpedo-boat that appeals strongly to the popular mind: and the notion of a hermetically sealed craft running safely and certainly within the ocean's depths carries most of us back to Jules Verne's fanciful story of "Twenty Thousand Leagues Under the Sea." While the best of modern submarines but modestly approaches in accomplishment that Frenchman's imaginative creation, still, within the past few months, results have been attained in the United States that have gone a long way toward scattering the last vestige of official scepticism in the Navy.

To the older men of the service, the modern battleship has seemed the logical climax of naval architecture, and to command such craft has been the ambition of these men as they have slowly climbed the ladder of rank. To them, these wonderful fabrications, costing millions, have seemed the only rational guardians of our coasts and our seaborne interests, and, moreover, they have deemed the battleship the only proper instrument of control befitting their rank and their years of zealous devotion. Naturally these veterans in service scouted the idea that the small, modest-costing submarine could be the deadliest enemy of these beautiful floating fortresses. That notion, if it proved correct, would strip these officers of the dignified setting to which they had aspired for years. They would never be expected to command such tiny craft, and certainly it were not possible that naval progress had gone so far astray! To this opposition of the older men—whose counsels usually prevail—were naturally added the vigorous objections of all the great shipbuilding and armor-manufacturing interests of the country, to whom, especially, a policy of that sort would mean the annual loss of many millions of dollars.

To the youth of the navy, however, the submarine made instant and lasting appeal. In such service there would be touches of bravado and a dash of romance, together with the possibility of great deeds. To these embryo admirals the submarine seemed all that its most ardent advocate claimed. In a measure, this unthinking enthusiasm has done much to hurt the cause of this particular type of fighting craft. The true value of the submarine lies between the extreme views heretofore commonly held by the older men and those that characterize the younger men in the navy. Such is its present position, while its full fu-

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ture worth, of course, is still a matter only of speculation.

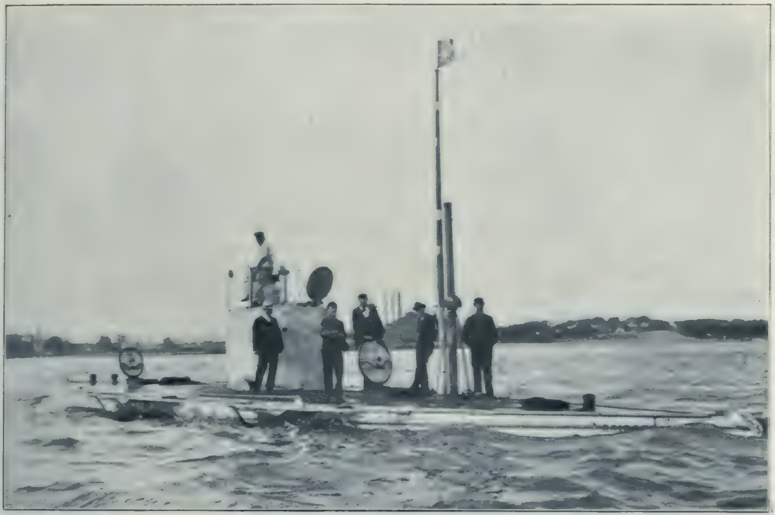
It is common knowledge that no modern armored ship has yet been sunk in battle by gun-fire alone; and although the gun, as a result of proving-ground tests, has been declared the master of armor-plate when tried under conditions peculiarly favoring the attack, a great chance remains that the palm of victory in battle will go to that ship—the vessels being equal—which successfully lands a torpedo against her foe's thin sides below the armor-belt. All readers of the technical press will recall the experimental attacks made against the old British armored ship *Belleisle,* and they will recall how repeated and deliberate exposure to the fire of modern high-explosive shells failed to sink the craft. It was only a few weeks ago, however, that a torpedo, at one discharge against a specially prepared defense, ruptured the side of the vessel so that it was only with difficulty and by the exercise of the utmost dispatch that the ship was beached before she sank. The lesson was an obvious one. The value of the torpedo had heretofore been underestimated.

The mission of the submarine is to attack the vulnerable sides of heavy fighting ships lying below the armor-belt and below the water-line, and there, by the delivery of one stunning blow, to accomplish more than the awful pounding aboveboard of the heaviest of modern great guns. Such is the *raison d'être* of the submarine, and the protecting folds of the surrounding water mean for her that armor which otherwise she is denied. Exposed for even a few seconds to the gun-fire of a watchful foe, her destruction would be well-nigh certain.

THE "HOLLAND" BOAT *MOCCASIN*, AFTER A PRACTICE SPIN OFF NEWPORT, R. I.

Lieutenant John Halligan, Jr., U. S. N., recently wrote:

> "The present state of development of the submarine with its automobile torpedo, is such that when the boat is submerged and within torpedo range, it must be admitted that the disablement or destruction of the battleship is probable—the degree of probability and the amount of damage depending principally on the number of torpedoes that can be discharged by the submarine, and on her facilities for



THE "LAKE" BOAT *PROTECTOR* IN CRUISING TRIM.

locating and estimating the range of the target."

Finally he says:

> "When the earnest call for the submarine comes, the final measure of comparative worth of existing types will rest upon their ability to attain a position of advantage against the enemy."

This position of advantage means getting within a torpedo range of something like four hundred yards.

The French, whose experience of modern submarine craft covers a longer period than that of any other nation, have classed their boats of this order into "submarines" and "submersibles." The main distinction is one of endurance. The "submarine" has a limited radius of action, and, at all times when operative, is sealed ready for instant submergence. The "submersible," on the other hand, has a surface cruising endurance and condition analogous to that of the ordinary torpedo-boat of moderate speed. In this state, she is run under steam or by means of gasoline engines, her hatches are open, and she is generally navigated from on deck. To prepare her for submergence, it is necessary to reduce her buoyancy by taking in a number of tons of water, and, when the craft is ready to act as a submarine, all air vents are closed and the boat is put under electrical propulsion. The "submersible" typifies the higher order of modern submarines, for she is self-contained, her gasoline or steam engines being used to recharge her storage batteries. In the case of the true "submarine," on the other hand, this must be done at a shore station.

The two submarine torpedo-boat types now before United States naval officials are the "Holland" and the "Lake," named, respectively, after their inventors, Mr. John P. Holland and Captain Simon Lake. The Holland type is the one now exclusively represented in our navy, while the Lake boat is the formidable competitor for recognition under the act passed at the last regular session of Congress, providing half a million dollars for trial by competition and for subsequent purchase of the best submarine or sub-surface torpedo-boat in the American market. To a certain extent, the result of this contest for points means the death of one enterprise and the advancement of the other. The new boat asks only a fair field and no favor—representing, as she does already, private enterprise involving nearly three hundred thousand dollars; and the patriotic American asks only for that boat which, within its field of usefulness, is best adapted to safeguard our national interests.

The Holland boats, while partaking somewhat of the nature of the French "submersibles," are strictly to be classed with the Gallic "submarine" when judged by their sea-going or sea-keeping performances up to the present time; while the Lake boat *Protector* is the French "submersible" much improved. The reasons for these differences are those peculiar to the model and the principle upon which each has been built. The Holland boats belong to what is now termed the "diving" type of submarine; the *Protector* is of the "submerging" type—an order of craft permitting a wide range of adaptability and promising still greater things in the future. This is not said in derogation of the Holland boats, for, within their necessarily restricted field of evolution, their present development is the result of skill of a high order. The palm, in the future, however, must go to that type which is proved to be constructed on the broadest principles.

The "diving" type differs from the "submerging" type only in the method employed in getting beneath the surface. To the layman this may seem immaterial, so long as each is able to get rapidly under cover; but practical experiment has proved to the contrary. The two boats, when running under the surface, do so by overcoming a constant tendency to rise, due to a certain amount of reserve buoyancy. This reserve buoyancy ranges generally in the neighborhood of 150 to 200 pounds. In the "diving" boat—the craft being under way—this buoyancy is overcome by the aid of two horizontal rudders at the extreme stern. To make the boat dive, these rudders are given a downward dip of sufficient degree to effect a destruction of the longitudinal stability of the craft and to cause her to plunge headforemost beneath the water. To make the vessel sufficiently sensitive to these horizontal rudders, the boat must be as nicely balanced as a pair of scales in equilibrium. Weights must not be shifted in a fore-and-aft direction during the periods of submergence, and the men must remain nearly immobile at their stations.

Upon one man, however, rests the brunt of successful submergence and the burden of insuring safety, and he is the man controlling the wheel that governs the horizontal or diving rudders. His task is nearly akin to that of the tight-rope equilibrist, the wheel of his controlling gear being the counterpart of the other man's balance pole. Directly facing him is a large depth-gauge upon which his eyes are riveted; and his is the task of watching the fluctuations of that tell-tale pointer, and, as far as human skill can do so, of anticipating the movements of the craft up or down. At best he can maintain only an approximately uniform depth, and the course of the vessel in any case is of necessity sinuous. Because of the boat's delicate balance, the Holland type, when submerged, is very sensitive to the influences of currents, eddies, and the sub-surface effects of waves, all of which add to the task of the diving-rudderman. When running "awash"—that is, ready for instant diving—these vessels are very sensitive to a seaway, their spindle-formed hulls tending to "bury" by the head as the waves tumble onto their bows, thereby making them sluggish and keeping them so low in the water as to render it nearly impossible to observe an objective through the ports of the conning-tower. Besides, this action of the waves gives the boats a constant impulse to dive. The Holland boats cannot be made to dive when going at less than six knots an hour, and, on coming to the surface for observation through the dead-lights in the conning-tower—their optical sighting tubes having proved generally unsatisfactory—these vessels "broach," or break water, and show almost their entire length in "porpoising" for a new dive. Apart from the tell-tale disturbance thus made and the possible target thereby offered to an enemy's rapid-fire guns, sufficient warning of the course of the submarine is given to enable the much swifter surface craft to avoid attack.

Ground for the assertion that the Holland boats properly belong to that class restrictively designated as "submarines" by the French, is found in their sea performances. Under very favorable conditions of weather, one of the Holland boats once made a short surface run under her gasoline engines, but even then she was under convoy. Since that time the boats of the Holland type have uniformly been towed from port to port. Some naval experts have advocated this method of taking the submarine from a base of action to the field of operations, and the towing vessel has not inappropriately been dubbed the "mother ship." As the boats are not fitted for habitation for a longer period than a few hours, it is the practice to transfer the crews to the towing ship, attach a tow-line to the bitts of the submarine, and drag her to her destination. The term "drag" is used advisedly, for even at the moderate speed of six knots, the vessels are hard to tow. How disastrous this tow-line method is, was proved by a recent mishap to the submarines *Adder* and *Moccasin* on their way into the Chesapeake.

The ability of the Holland submarines to get within striking distance before detection, has never been established in spite of all the experiments made last summer and during the early fall around Newport, R. I. The writer has been informed by officers at the United States Torpedo Station that never once did the boats get within torpedo range without being discovered, and at no time was the target a moving vessel. What the boats, with an efficient observing instrument under certain favorable conditions of the sea, might prove to be capable of, is a matter for speculation; but, because of certain inherent peculiarities, they do not now meet the maximum requirements of a successful submarine torpedo-boat.

R. C. Skerrett
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THE *PROTECTOR* READY TO GO UNDER AT A MOMENT'S NOTICE.

The *Protector,* of the Lake type, is purposely almost identical in general dimensions of length and maximum beam with the boats of Holland design belonging to the Navy; but beyond that, she is a distinct departure. To the main spindle-shaped body—designed to withstand water pressure at a depth of 150 feet—is added a light, ship-shaped superstructure. The purpose of this superstructure is two-fold, and is the result of some years of practical experience gained by Captain Lake in his *Argonaut I.,* built in

1897, and his *Argonaut II.*, a remodeled form of the earlier vessel, built in 1900. The superstructure gives to the craft great buoyancy and a seaworthiness that is denied to the spindle-shaped hull. Such was its primary purpose. The second purpose in its design was to form a convenient and safe storage for the explosive gasoline and the high-pressure air-flasks. By keeping these out of the main spindle hull, the danger of gasoline leaks was minimized, and space was secured for other much-desired uses. Some notion of the seaworthiness of the *Protector* may be had from the knowledge that she recently made the run of 110 miles from Bridgeport, Conn., to Newport, R. I., having in tow a large sloop; and that she pulled this vessel around Point Judith in the teeth of half a gale from the southeast blowing in directly from the full sweep of the Atlantic.

THE "PROTECTOR" RUNNING AT FULL SPEED, WITH ONLY THE OMNISCOPE ABOVE WATER.

To bring the *Protector* to war-time cruising trim, the superstructure is filled with water, at which time her broad deck is awash. To bring the boat to submerging trim, it is necessary to fill her ballast tanks with water enough to bring the top of her conning-tower awash. At this point her armored sighting-hood is above water, and the vital hull of the craft is six feet below. In this condition, the boat has two hundred or three hundred pounds of reserve buoyancy; and further refinements of submergence, involving finally nothing but about a foot of the omniscope or sighting instrument above water, are within the immediate control of the commanding officer. In the condition with the sighting-hood above water, the boat is forcibly submerged by the operation of four horizontal rudders, or, as Captain Lake terms them, "hydroplanes," which are large, flat, rectangular paddles pivoted in the center and located in the guards on line with the superstructure deck. These hydroplanes are moved in unison, and, being symmetrically disposed, bring pressure to bear at four equidistant points. When the boat is under way, a dip of the forward ends of these hydroplanes brings pressure to bear upon their upper surfaces, thereby causing a downward thrust, the pressure depending upon the speed of the boat and the angle of the dip. When this pressure overbalances the reserve buoyancy of the boat—that constant tendency to rise to the surface—the *Protector* sinks on an *even keel* below the waves. As deliberately as she sinks, just so deliberately does she come to the surface, exposing gradually to view nothing but the modest target of the head of her omniscope. As it is possible to submerge the *Protector* at any speed, there is, of course, no risk of the boat "broaching" when coming to the surface. With even a gently disturbed surface for a cover, it would be possible for the *Protector* safely to drift down upon a foe, or to creep upon her at a slow speed, to within torpedo range, without the slightest fear of detection, even in broad daylight.

Because of the hydroplane method of submergence, it is not necessary that the *Protector* should be delicately balanced. Her longitudinal stability is so great that large masses may be shifted and the crew permitted to move with the utmost freedom, when the boat is running below the surface. Apart from the freedom from restraint and the absence of nervous tension upon the crew, this preservation of an even keel bears directly upon the working efficiency of the craft when under water. When only the sighting instrument is above the surface, even in a considerable sea, the boat lies steadily. This permits increased range of vision. When the craft is totally submerged and is steering a compass course, the compass, because it is not disturbed by any rolling or pitching motion on the part of the boat, as is the case with the diving type, is a true guide of direction; and it is thus possible to run with precision. It is also possible to preserve substantially a uniform depth, because with the hydroplanes set and the electric motors constant, only that depth will be attained at which the upward thrust of the water balances the downward push of the pressure on the hydroplanes. The maintenance of this depth, once chosen, becomes nearly automatic.

Now, to get within striking distance of the enemy depends greatly upon the efficiency of the omniscope. This instrument—unlike the altiscope of the boats now in the Navy, which has only a limited, fixed field of vision forward—commands the whole horizon by the aid of four finder-lenses; while a fifth lens, which can be brought to bear upon any point, gives normal vision and a means of reading distances correctly, which is impossible with the present type of altiscope. The omniscope of the *Protector* has been tried under all conditions, and has been found entirely satisfactory. So much for the means of getting within striking distance.

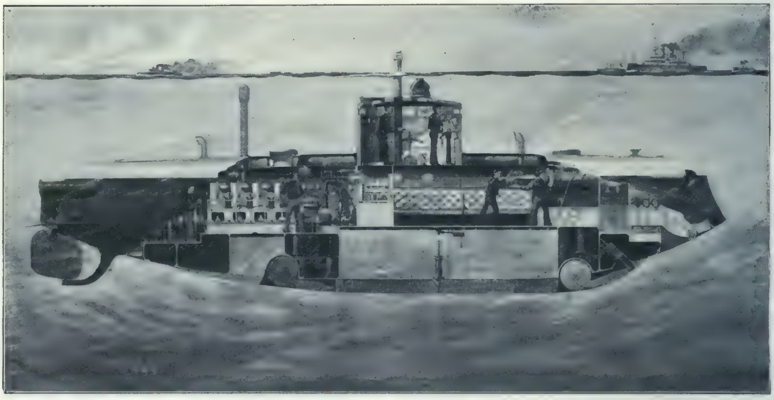
The offensive power of the *Protector* is centered in three torpedo tubes—two forward and one aft. The two forward tubes can be fired simultaneously, while the after one is intended to be discharged after the boat has turned for flight. The Holland boats carry three torpedoes, but have only one torpedo tube; and, moreover, in order to recharge the tube, a boat of this type would have to come to the surface, and would lie there a target for a foe's guns for the considerable period of time required for reloading.

THE "PROTECTOR" TOTALLY SUBMERGED.
The mast is no part of her military equipment.

For the purpose of seeking shelter upon the bottom within a depth of 150 feet, or for under-running and countermining an enemy's mine fields, or for entering an enemy's harbor by following the bed of the channel, the *Protector* has two great wheels upon which she can travel along the bottom, the driving power being supplied by the screws. To enter an enemy's harbor, all that would be required would be to steer the charted courses, the depths being given by the depth-gauge, while the distance traveled would be recorded by the odometer attached to the wheels. To enable the boat to cut mine connections and submarine cables, the diving compartment—in principle a diving bell—permits a diver to pass out from the boat and onto the water bed. This compartment is the foremost division of the craft. Next after this comes the air-lock, by which intercourse may be had with the rest of the boat—not under pressure—while the diving compartment is in operation. Abaft the air-lock are living quarters designed for eight men, where comfortable folding berths and transoms afford ample sleeping accommodations. Next abaft the living space is the pantry, where cooking is done by electricity, while the aftermost compartment is given up to the gasoline engines and the electric motors. The engine-room is a wonderful example of skillful installation. There is a wide, free passage between the engines, and space enough overhead for a six-foot man to stand upright.

In the conning-tower, quite naturally, centers most of the interest in the boat, for from this point the commanding officer has complete personal control of the entire craft. This conning-tower is large enough to accommodate four men. In it are all sorts of gauges, registers, indicators, means of communication, and facilities for control. The commanding officer, the steersman, and the man at the hydroplane wheel are in constant touch with one another, while automatic indicators advise the steersman and the gunner at the bow torpedo tubes of the proper bearing of the boat.

When running under gasoline propulsion alone, it is possible to submerge all but the omniscope and a valve on top of the sighting-hood which automatically closes against the admission of water. When running totally submerged, the boat is under electrical propulsion. The two motive powers are so arranged that they may be coupled in together for dashes covering periods of from four to eight hours; and it is possible to couple in the motors with the engines at lower speeds so that the motors become dynamos and recharge the batteries while the boat is still going along at a considerable speed.



FORE-AND-AFT SECTIONAL VIEW OF *PROTECTOR*, SHOWING DETAILS OF INTERIOR CONSTRUCTION.

The habitability of the *Protector* has been proved by months of service, in which her crew have lived aboard. For protection against the chill of winter weather, the boat is equipped with electrical heaters.

It is not possible, in an article necessarily limited as this must be, to go into the full technical detail of this vessel, but enough has already been given to furnish a fairly adequate idea of the practical working plan of this craft and of the submarines now in the Navy. In a circular issued in 1893 by the Navy Department, in which the broad requirements of submarines were laid down, prime emphasis was placed upon the element of safety. The Holland boats, if they go to the bottom, can rise again only by exhausting their ballast tanks. The *Protector,* besides being able to free herself of that weight, can instantly drop a five-ton emergency keel and let go two anchors weighing together a ton; and, in addition, the escape of the crew, if all other efforts fail to release the boat, is assured by means of the diving compartment, the practicability of which has been demonstrated.

Wonderful as the *Protector* really is—and she has established her claims to recognition only after months of service—still she is but the beginning of what her inventor has planned along these lines. The inventor of the Holland type did the nation a great service in giving to the submarine in the United States a standing it had never enjoyed before, but it is to the possibilities of the more recently developed Lake type of submarine torpedo-boat that the present position of this country at the head of the world in this important branch of naval architecture is apparently due.

THE THIRD-RAIL SYSTEM

A POPULAR TALK ON A SUBJECT OF GREAT INTEREST TO ALL CONCERNED WITH THE PROBLEMS OF ELECTRIC RAILWAY RAPID TRANSIT

By H. M. Brinckerhoff, M. W. S. E.

Superintendent Metropolitan Elevated Railway,
Chicago, Illinois.

CHICAGO has been the pioneer in third-rail work, beginning with the Intramural Railway at the World's Fair, down to the present time. She now has the most complete and best-equipped elevated railway system in the world, and one that is being patterned after by the systems in other cities, in some cases with a closeness in detail that is really amusing.

The first commercial third-rail system operated in this country was the Intramural Railway at the World's Fair, built for the purpose of affording transportation from point to point on the grounds. This railway went into operation almost simultaneously with a third-rail system in Liverpool, England; and it was a curious fact that many of the details worked out entirely independently on both sides of the ocean for these systems were remarkably alike in many of their features.

The Intramural Railway consisted of a line of double track extending about the Fair grounds, three miles in length from end to end, with a loop at either terminal. Trains of four cars were run, each car having a seating capacity of fifty passengers. The head car of the train was equipped with motors, giving what is now known as the locomotive system, as distinguished from the multiple-unit system in which motors are placed in all the cars, the latter being the one used on the South Side Railway of this city.

At the time the concession was let by the World's Fair authorities for this elevated railway about the grounds, the only known way of supplying electric power to cars, in successful use, was by the overhead trolley. In fact, some of the first sketches submitted to the Fair authorities showed poles and overhead conductors. The use, therefore, of a flat shoe sliding on a steel rail was a radical departure; and so general and severe were the criticisms of the scheme, even from men considered authorities on such subjects, that it was with considerable trepidation that the first trial trip was made.

In this feature, then, as in many others developed in designing the equipment of the Intramural Railway, there were no precedents to be guided by; and various questions which have since been discussed at length, such as the location of the contact rail, the advisability of equipping the motor car with two or four motors, the best method of subdividing the feeder system, the arrangements for the return circuit, and the proportion of the power station capacity to the maximum load to be hauled, had all to be worked out without any reliable data upon which to base the calculation.

The fact that this third-rail system has been adopted by all the elevated railways in Chicago, Brooklyn, Boston, and, finally, New York, as well as on some interurban and steam railway lines, naturally leads to these questions:

> What are the features of the electric third-rail system which have caused its almost universal adoption on elevated railways?
>
> Under what conditions can it be used on interurban and steam railway lines?

Briefly, the third-rail system is merely a method of supplying trains on an electric railway with current, and differs *only in detail* from all other electric systems where the power is generated in a central plant and distributed by suitable conductors to the cars on the various lines. In starting a five-car elevated train from 500 to 800 or even 1,200 amperes are required. If such currents were passed through a trolley wheel, such as is used on street-railway cars, very excessive arcing would be caused, due to the fact that the wheel touched the wire at only one point. The contact surface is not sufficient to carry this current, and burning of the wheel and trolley wire result. With a sliding shoe, however, instead of a single point of contact, you have a surface about six inches long by two inches wide, and two of these in use at once under normal conditions. In other words, the third-rail system differs from the ordinary trolley road only in detail. These details, however, are such as to make possible the application of electric traction to heavier trains than has been found practicable with the overhead trolley, and the system has thus broadened the field for the application of electricity to railway work, so as to bring it into successful competition with steam for the heaviest classes of service. The reasons for its general adoption on elevated roads were on account of the advantages peculiar to *electric traction itself*—namely:

INTRAMURAL ELECTRIC RAILWAY, COLUMBIAN EXPOSITION, 1893.*

1. Reduction in cost of power for handling trains.
2. Increase in passenger handling capacity.
3. A service more attractive to the public generally.

The reduction in the cost of power is obtained largely from the generation of power in a single central steam plant, instead of a great number of smaller plants, as with the steam locomotive system. On this point of economy, the fuel bill is one of the large items in the operation of a railroad. With steam locomotives, such as were formerly used on the Chicago elevated roads, the only fuel available cost in the neighborhood of $3.50 to $5.50 per ton, whereas, in the modern power house, designed for electric railway systems, coal ranging from $1.25 to $1.75 a ton is burned with entire success. When to this is added the enormous loss in radiation from a large number of steam locomotives, exposed as they are in running over the line of the road, and we compare this with the relatively small loss experienced with a well-constructed stationary boiler plant, it is not surprising that the cost for coal per car mile on the electric railways in Chicago is about *one-third* the cost per car mile with steam locomotives. The comparison is particularly favorable in this city on account of the ability to obtain a very cheap grade of coal directly from the Illinois and Indiana coal fields. In New York and other eastern cities, this difference is not so great, as coal delivered at those points is necessarily higher in price on account of larger freight charges. Besides the saving in the coal bill, there is a further gain by the use of large compound - condensing engine units. These large steam units having a comparatively steady load, develop power with a very much lower steam consumption than the small engines of a locomotive with their constant starting and stopping, and consequent cooling of cylinders, etc. Another item in which a considerable saving is made is in the cost of repairs and renewals to the motor equipment as compared with locomotives.

The second advantage—increase in capacity for handling passengers—is due, first, to the fact that with electric motors a much higher rate of acceleration can be obtained in starting trains, thereby increasing the average speed over a given line of road. The trains can also be handled with so much greater accuracy and precision that a much shorter interval is perfectly safe, all of these directly contributing to the end of greater capacity. The great importance of this feature you will see more clearly when I explain to you later what we are doing on the Union Loop in the rapid handling of trains. We are accomplishing things there that would be impossible with steam locomotives.

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* Illustrations for this article supplied by courtesy of the Western Society of Engineers.

The third item—service more attractive to the public generally—is proved by the facts of the absence of smoke and steam, and the great reduction in noise, these being especially important in systems passing through the heart of a large city, as is the case with elevated roads.

In regard to the use of the third-rail system on interurban roads, the same general considerations apply as to the economy of operation, except that, trains being less frequent, the economy in the power generation is not so great an item.

There is another field for the third-rail electric railway system, which has been developed by the New York, New Haven & Hartford steam road, and that is the use of light trains for suburban and interurban service on many of their branch lines.

In regard to fencing the right of way on a surface third-rail system, it is interesting to note that the managers of the Albany & Hudson Railway, and the N. Y., N. H. & H. Railway state that injuries due to the third rail are rare, and that with proper signs and fencing the accidents on the systems as a whole are no more frequent than on any ordinary steam road. From personal observation and experience I can state that a man of ordinary intelligence needs only one good jolt from a railway circuit to make him very respectful in future toward all bare conductors.

A very large interurban electric railway system with the third-rail equipment is now in operation from the Fox river valley to Chicago, and is known as the Aurora, Elgin & Chicago Railway. The right of way is entirely private, except in Aurora and Elgin; the road-bed is of the heaviest steam construction, with stone ballast, stone bridges, and but few grade crossings. The equipment for this road is on steam railway lines, as far as luxury and elegance of appointments are concerned, the cars being equipped with motors of sufficient power to drive the train at a maximum speed of seventy miles an hour.

It is perfectly possible to haul the heaviest kind of passenger and freight trains with electric motors, as has been demonstrated by the Baltimore & Ohio Railroad, at Baltimore, Md., where they handle through the tunnel all their trains, both passenger and freight, to avoid the smoke and other objectionable features of locomotives. To obtain, however, the greatest benefit in the economy possible with the electric system, the service should be such as to employ frequent trains of light weight, which gives a steadier load upon the generating plant. This also has a tendency to increase passenger traffic due to greater accommodation afforded the general public. It is stated by the manager of the Albany & Hudson Railway, Mr. Maurice Hoopes, that it is actually cheaper by about 23 per cent to equip an electric railway with a third rail instead of the overhead trolley. In this estimate, the rail figured on is of special composition, giving a conductivity of 8 to 1 as compared with copper. He also states that the cost of maintenance is very much lower, and the system more reliable, owing to the absence of delays resulting from the trolley coming off the wire and from the wrecking of the line by striking cross spars or pole brackets. This is a difficulty with an overhead trolley that is hard to overcome when running cars at forty or fifty miles an hour.

H. M. BRINCKERHOFF.

In designing the original sliding shoe and third rail for the Intramural electric railway, what was required was an ar-

NEW YORK, NEW HAVEN & HARTFORD ELECTRIC RAILWAY.
With third rail between track rails.

rangement that would be capable of supplying large amounts of current to a great number of heavy trains, without burning of contact surfaces, and which would also operate around sharp curves, over crossings, etc., at a high speed without special attention from the motorman or conductor. That the requirements were met by the sliding cast-iron shoe on a steel rail, is proved by the wide adoption of the device and the very slight variations in detail that even six years' use has suggested.

The first shoes experimented with were made of a composition having a large percentage of copper, and in order to insure contact the device was so designed as to allow of the insertion of a heavy coiled spring to force the shoe against the conductor rail. A few days' trial demonstrated that these shoes would wear out with such rapidity as to prove an enormous expense. Cast-iron shoes were then tried and with better success, though still retaining the spring, but even these wore out rapidly. It was not until case-hardening the surface and other similar expedients had been attempted that it was decided to abandon the spring; and we were surprised to find that the arcing without the spring pressure was not appreciably greater than with it, and that the shoe lasted practically indefinitely. The process seems to be that after a few hours' run the frictional heat generated by sliding over the contact rail hardens the surface of the cast-iron shoe so as to make it resist the wear.

Shoes are running about two and a half years on the Metropolitan Elevated, or about 150,000 miles, and are made of ordinary cast iron. On account of the constant motion of the shoe, due to the inequalities of the rail and the relative movement of the car, the electrical connection is made by a flexible cable, each end being soldered into a terminal attached respectively to the shoe and the main casting. Four shoes are attached to each car, and in this way it is possible to locate the contact rail so as to insure a supply of current for the cars at all points on the road.

Having decided upon a sliding shoe and rail, the next important question was the location of the contact rail. Only two feasible positions suggested themselves: First, the center of the running track directly beneath the car; and, second, on the outside of the running track at a convenient elevation.

At the first glance the central location seems the more natural. When, however, it is attempted to carry such a system through a complicated set of switches—particularly where slip switches are used, as in the yards or crossings—great difficulty is experienced in insulating and at the same time locating the contact rails so as to give a continuous supply of current to the train in passing over the various routes. Also, the distance between the bottom of the motor, which is suspended from the truck, and the top of the running rail, is so small that when crossings occur it becomes very difficult to insulate the rail properly and at the same time give it mechanical support. Again, the dropping of the brake rigging or any other apparatus, would of course mean its falling directly upon the live rail, if located centrally, causing short circuits and consequent interruptions in the system.

Another point to be considered is the necessity, at times, when the electrical apparatus of the car is grounded, of lifting the contact shoes from the third rail. This is an extremely difficult matter with the shoes located directly beneath the car. On the other hand, the rail placed at the side of the track can be elevated to a height that will render possible a thoroughly mechanical design for the insulating block. It also leaves it accessible for repairs by trackmen, and makes the problem of lifting the trolley shoes an extremely simple one.

In working out the details for some four-track slip-switch crossings on the Metropolitan Elevated, it was necessary to use movable contact rails; that is, rails which are thrown from one position to another in connection with the track switches. These movable rails are connected with the interlocking levers, in some cases being raised and lowered, and in others swinging sideways, in order to bring them to the necessary position relative to the various routes over which the cars are intended to pass. We have succeeded, even at the most difficult crossings, in designing movable rails which work in a thoroughly satisfactory manner, but this could not have been done with a contact rail located in the center of the track.

BRIDGE OVER DESPLAINES RIVER, ILLINOIS.
A specimen of steel construction.

The use of the ordinary track rail for the conductor was largely a matter of convenience in the first case, as rails were the easiest form of steel to obtain in reasonable lengths, and their shape was such as to lend themselves to the various requirements of attaching bonds, angle bars, and insulating supports. The price of rails in 1893, when the Intramural was equipped, was so low that it was cheaper to put in an additional rail alongside the contact rail as a supplemental feeder, than to buy copper for this purpose; and the Metropolitan feeder system, as originally installed, consisted of steel rails, known in the trade as "seconds," bought at about $17.00 a ton. These rails were placed upon insulating supports between the running tracks. The foot-walk for the convenience of trackmen, was placed above them, so that to the casual observer nothing was apparent but the ordinary contact rail.

The value of an ordinary commercial steel rail as an electric conductor, as compared with copper, is about 10 or 12 to 1, with of course the additional disadvantage against the rail of the necessity of the frequent bonding, the rails usually coming in 30-foot lengths. To offset this lower carrying capacity, however, compare rails at $17 per ton with copper at $360 per ton, and it can be seen that one can afford to put in the larger amount of steel required for a given electrical capacity and still have a good margin in favor of the rails. With the present price of rails, however, this argument would not hold true. The rails referred to as "seconds" are rails that have been rejected on inspection on account of some defect which makes them unfit for track work, and yet leaves them perfectly good for electric conductors where no mechanical strain is put upon them. A commercial 80-pound track rail has a carrying capacity about equal to an 800,000 c. m. copper cable. In purchasing the contact rails for the extension of the Douglas Park line, they were made of steel of a special chemical composition, having a higher electrical carrying capacity than the ordinary commercial steel rail. The composition was obtained after a series of experiments conducted for the Manhattan Railway in New York City, with a view to getting the best possible conductor with a composition of steel that could be successfully rolled into rails. The use of this composition results in a steel rail so soft as to be unfit for ordinary railway service, but the conductivity is raised so that, compared with copper, the ratio is about 8 to 1, as against 12 to 1 for ordinary commercial steel rails.

Experience has shown on the Metropolitan Elevated system, that with feeders composed of steel rails they can carry enormous overloads without danger from heating; but there are some necessary repairs and inspection of the bonded joints, which would be avoided by the use of copper cables.

On the Northwestern Elevated, in Chicago, aluminum cables have been used at a considerable saving in the original outlay, as this material costs for an equal carrying capacity about 30 per cent less than copper, the relative value as conductors for equal cross-sectional areas being in proportion about 63 to 100 for copper. There are two difficulties which have developed in the use of aluminum cables, one being the fact that the relative expansion with changes of temperature is very great, so that a cable pulled taut in cold weather will have an immense amount of slack with a rise in tempera-

DISTRIBUTING CONDUCTOR CABLE.

ture, as frequently happens in this climate, and *vice versa.* Another point is the difficulty of making the joints where connections are necessary, as the ordinary process of soldering or sweating the joint, as is done with copper, cannot be used.

DISTRIBUTING CONDUCTOR WIRES.

Here is a chemical analysis of commercial and special steel rails for conductors:

	Commercial Rail. Per Ct.	Manhattan Rail. Per Ct.	Albany & Hudson Per Ct.	Metropolitan Per Ct.
Carbon	.47	.073	.09	.09
Manganese	.76	.341	.44	.50
Phosphorus	.104	.069	.088	.100
Sulphur	.03	.073	.08	.053

The commercial rail gave a resistance of 18.2 microhms per cubic centimeter, or a ratio to copper of 10 to 17. The Albany & Hudson gave a resistance of 12.9 microhms per cubic centimeter, and has about 7.25 times the resistance of commercial copper.

One of the most difficult problems in equipping an electric railway system is the proportioning of the total capacity of a power house to the number of cars run, and the subdivision of this total capacity into proper-sized units. In order to determine these points, it is necessary to be able to estimate the maximum loads that will have to be carried during the rush hours, and the minimum loads during midday and midnight. The maximum load does not always depend upon the total number of trains run,as in some lines more than half of these trains will be running light in one direction in order to carry the crowds back on their return or vice versa. On other systems, travel is more equal. Again, the distance between stations, grades over which trains must be operated, and the running time that will be required in order to meet competition with other lines, all enter into this problem.

The question of heating cars is a more serious item than is generally realized, if this is to be done electrically. In extreme weather, when all the heater circuits in a car are thrown on, it takes forty per cent of the total current required for the train, for the heating. The average amount of current used for heating from November to May, however, is only about twenty per cent of the total used in train operations. In subdividing the total capacity of a power house, it is desirable to have a single unit which will carry the minimum light load with reasonable economy, and if the subdivision of the total capacity of the power house into units of this size does not give too large a number of engines, such an arrangement will be found most convenient for repairs, as various parts will be interchangeable.

The load on a power house operating in connection with an elevated railway system, such as in Chicago, varies not only from a maximum during rush hours to minimum during off hours, but also momentarily during the starting and stopping of trains, these fluctuations being most violent when the least number of trains are in service. Under the worst conditions, this rate will vary from 300 amperes to 4,000 in fifteen seconds, or the reverse. It is necessary, therefore, that all parts of the engine should be especially heavy, particularly the fly wheel, in order that sudden changes in the load should not interfere with the proper regulation of the engine speed. To take up such violent fluctuations, storage batteries are sometimes used, as on the South Side road.

The accompanying diagram, Fig. 1, shows a typical load curve at the power house. Curve A is that of the trains in service. Curve B shows the additional amount of energy for heating the cars, with heaters only partly turned on during the rush hours; while curve C gives the total load with heaters turned on full during the rush hours. The high peaks of the curve occur at the rush hours of travel.

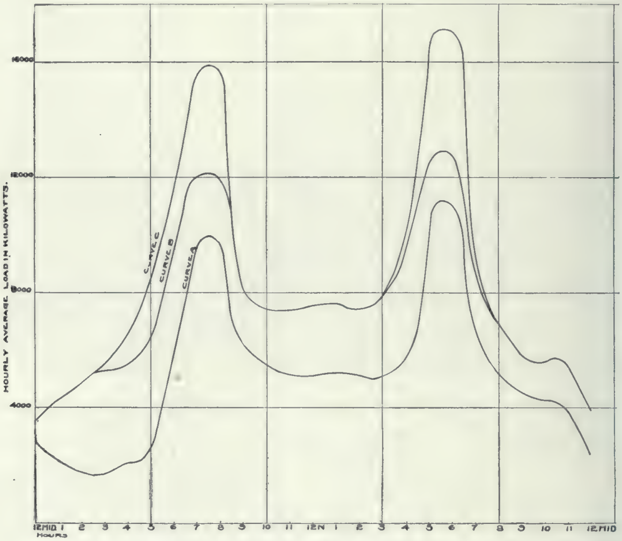

DIAGRAM SHOWING TYPICAL LOAD CARRIED AT POWER HOUSE OF METROPOLITAN ELEVATED RAILWAY, CHICAGO, FOR 24 HOURS.

The second diagram, Fig. 2, shows the violent fluctuations in the demand for electrical energy for operating the trains.

The Aurora, Elgin & Chicago Electric Railway probably affords the best example of heavy high-speed electric railway work to be found in the world. Between Wheaton and Elgin, and between Wheaton and Aurora the country is without any large villages, though it is a thickly settled and productive farming country all the way. The syndicate controlling this company has also acquired control of the electric lines connecting Aurora, Batavia, Geneva, St. Charles, Elgin, and Carpentersville.

The chief interest on the road to the electric railway engineer, however, aside from the local situation, is the solidity of the construction, and the high speed at which trains are operated in this service. The motor equipment is designed and guaranteed to maintain a car at a maximum speed of seventy miles per hour on the level at normal voltage on the third rail. To insure this high speed, the motor equipment is the heaviest yet put on cars for this class of service. Each car has four 125-H. P. General Electric motors. The cars and trucks follow M. C. B. standards quite closely. The General Electric multiple-unit or train-control system is put on all cars. Cars are run either singly or in trains. In case trains are made up consisting of as many as three cars, one of these cars has no motors, otherwise every axle on the train will have a motor. The track construction is of the most thorough character and renders it possible to attain a high maximum speed. From Chicago to Wheaton the line is double-tracked. From Wheaton to Elgin and to Aurora single-track lines are built. However, on the single track, the sidings are of considerable length to avoid loss of time at the passing points.

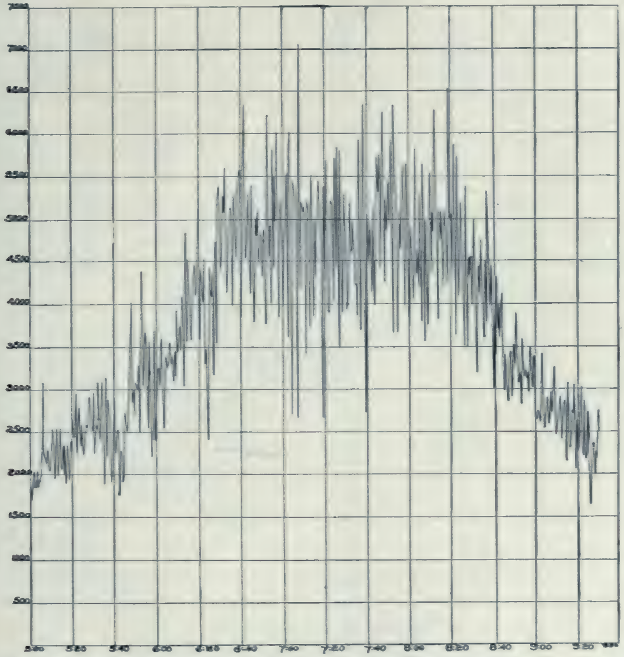

DIAGRAM SHOWING FLUCTUATIONS IN THE CONSUMPTION OF ELECTRICAL ENERGY
On the Metropolitan Elevated Railway, Chicago, at short intervals from 5 A. M. to 9:30 A. M., ranging from 1,700 to 7,000 amperes.

The road uses the third rail, except in the towns of Elgin and Aurora, where it does not run over a private right of way. The third rail weighs 100 pounds to the yard, and is located in the standard position (outside of the track rails) adopted by the elevated roads of Chicago and other cities. The conductivity afforded by this 100-pound section of T-rail is sufficient to obviate the necessity of any copper direct-current feeders. The power is transmitted at 26,000 volts over three-phase lines supplying sub-stations. All these sub-stations feed directly into the third rail, which is not normally sectioned, but the parts of which are tied together, so that the sub-stations assist each other. The power house is at Batavia, on the Fox river. From the power house, three three-phase 26,000-volt aluminum feed lines run out, with the arrangement such as to give duplicate feed lines to most of the road. One line runs directly from the power house to sub-station 1, at Aurora; from there to sub-station 2, at Warrenville; and thence to sub-stations 3 and 4, on the main line. Another line runs directly from the power house to the Warrenville sub-station, where it joins the high-tension line from Aurora. Another high-tension line running directly from the power house to sub-station 5, also runs northwest to feed sub-station 6, and continues east to sub-stations 3 and 4. Sub-stations 3 and 4 are therefore supplied from two high-tension lines, one of which comes from the power house by way of sub-station 5 and one by way of sub-station 2. The high-tension lines, therefore, practically form two loops, so that in case of a break anywhere on these lines, current can be supplied from the other direction, except in case of sub-station 6, which for the present has only one source of supply. The high-tension lines are carried on poles, 35 feet to 40 feet high, in the country, and 50 feet to 60 feet high in the towns through which the road passes.

About a year ago a French engineer visited Chicago, on a tour of investigation of the rapid-transit systems of this country. He was taken one evening, during the rush hours, to the junction of Fifth avenue and Van Buren street on the Union Loop, and was astonished at the rapidity and frequency of the train movements. He could not believe that this could be the normal daily condition. He stated that in Paris the law forbade his railway company from operating its trains at less than three-minute intervals, and these intervals were maintained by means of block signals. His road was a third-rail system running on a fenced right of way on the surface, and extended out through one of the suburbs much as the Lake Street Elevated goes through Oak Park.

To give some facts as to what is actually being done daily on the Union Elevated Loop, let me state as follows:

> During the month of January, 1903, 1,523 trains were handled every 24 hours on the Union Loop; or, in other words, one train every 56 seconds on an average during the 24 hours.
>
> During the rush hours from 5 to 7 P. M., 212 trains are handled, or one train every 33 seconds.
>
> During the fifteen minutes from 6:00 to 6:15 P. M., 46 trains are handled, or one train every 19½ seconds.
>
> During fifteen minutes in the A. M. rush, 54 trains are handled, or one every 16½ seconds.
>
> During one hour in the A. M. rush, we are handling 187 trains through this crossing, or one every 19 seconds
>
> We are loading on the Union Loop on an ordinary week day, 54,000 people from 5:00 to 7:00 P. M., and 40,000 from 5:15 to 6:15 P. M.
>
> To give an idea of the wear on the various frogs and crossings, there are 27,880 wheels passing through this junction every 24 hours.

THE TRANS-SIBERIAN RAILWAY

ITS POLITICAL, STRATEGIC, AND COMMERCIAL SIGNIFICANCE AS BROUGHT INTO SPECIAL PROMINENCE BY THE PRESENT CRISIS BETWEEN JAPAN AND RUSSIA

By ALFRED S. JOHNSON, PH. D.

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TYPES OF CHINESE.

EVEN sooner than was anticipated, the strategic value of the Trans-Siberian railway is being put to the supreme test. By enabling Russia to concentrate her armies rapidly on her Pacific frontier, this great intercontinental line—primarily a military road, but also of vast commercial and industrial importance—has become a prime factor in determining the question of dominance in Northern and Eastern Asia. This is an issue that apparently could be settled only as it is now being settled—by appeal to the final arbitrament of war.

By most of those who have watched the trend of Oriental politics in recent years, such an appeal has long been regarded as inevitable. In a certain sense, the present embroilment is merely an incident of a broader movement that can be traced back for many generations—the unavoidable clash that accompanies the meeting of migratory tides whenever populations of rival race are turned back upon themselves and forced to seek new fields of expansion, new arenas within which to work out their destiny. Its more immediate causes, however, are traceable to developments arising out of the war of 1894-95 between Japan and China. Through Russian intrigue at that time, backed up by the alliance of France and the tacit support of Germany, Japan was obliged to forego the fruits of victory, the greater portion of which she has since seen fall without an effort into the hands of her Muscovite rival.

To Japan, the issue thus raised is one of life or death. As an overcrowded insular power, it is absolutely essential to her proper growth that commercial supremacy in the Yellow Sea shall not be usurped by any hostile power. Russian control of Korea and the open-sea terminals thereby provided for the Trans-Siberian railway system, would insure Russian commercial supremacy in these Eastern waters. This would not only be a deadly blow at the commerce of Japan, but would ultimately involve a serious menace to the independence of the island empire. It would also immeasurably facilitate the realization of the Slavic dream of expansion, by enabling Russia effectively to absorb the northerly portion of China, with all that

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VIEW OF THE PORT OF VLADIVOSTOK,
One of the Pacific termini of the Trans-Siberian System.

that would imply of self-centered lethargy, despotic retrogression, and commercial exclusiveness. Like the earlier conflict between Japan and China, the present struggle between the children of the Great White Czar and the hardy islanders of the Sunrise Land centers chiefly in Korea and Manchuria and in the question of domination there. Its effects, however, must reach to all the corners of the earth, for in these days the interlacing of political and commercial relations includes all lands and makes stepping-stones even of the islands of the seas.

So vast are the material prizes at stake, so delicate the balance of political leaning among the outside powers whose interests will be more or less affected by the result, and so great the possibilities of unforeseen complication, that any attempt here in the way of prophecy would be foolish. Suffice it to say that on the present struggle between Japan, the doughty champion of Western ideals, and Russia, the semi-Oriental, semi-barbaric anachronism of modern Christian Europe, hang apparently the destiny of Asia, the rise or fall of the progressive spirit in the Eastern World, and the immediate welfare of more than one-third of the human race. At such a supreme hour, a higher hand than that of any Emperor or Council or conventional concert of powers overrules events. Such crises are the Gethsemanes of history, and we can only watch and wait.

It is significant, however, to note concerning the vast empire which strides like a Colossus athwart both Europe and Asia, that history hardly justifies the common awe of this mighty apparition of the North, in whose presence the nations seem to stand and tremble. In actual warfare, the history of Russia in modern times has scarcely ever seen her strength *unaided* put to serious test without failure. Peter the Great was vanquished by the Turks, being saved from utter ruin by Empress Catherine through methods that were scarcely military. In his struggle with Charles XII. of Sweden, Peter was routed, though his troops outnumbered the Swedes by ten to one, and in the end was victor at Pultowa only when the deadly climate had decimated and Cossack treachery betrayed Charles's little band. Russia's best armies were vanquished and her ancient capital seized by

VIEW OF THE TOWN OF CHELIABINSK,
One of the European termini of the Trans-Siberian System proper.

Bonaparte; and though his army was at last destroyed, it was by the Russian climate, not by Russian arms. A little before that, Russia had been beaten by Persia. In the Crimean War she was "whipped to a standstill" on her own ground; in Hungary she was merely Austria's ally; and even in her last war with Turkey (1877-78) she was saved from disaster through the assistance of Roumania.

On the other hand, in the field of peaceful though often menacing diplomacy, the Russian record has been one of all but invariable success. In this respect Russia's resources are equal to every emergency. Baffled in one direction, she usually has more than secured her ends by insidious advances in another. In the Balkans, on the Afghan border, on the Pamir, along the Amur, and in Korea, Manchuria, and the Leao-Tong peninsula, she has stealthily sought out the avenues of least resistance. On the one hand she makes France her avowed ally, and on the other secures the unformulated support of France's chief enemy, and even aspires to a semi-protectorate over Austria-Hungary. In Europe she poses as the chief bulwark of Christianity against the "Yellow Peril," and in Asia as the safeguard of Chinese territorial integrity against Western encroachment. In a word, her most characteristic rôle among the family of nations is that of Grand Master in the great diplomatic game of "bluff."

It was in view of just such a crisis as that which has now arisen that Russia, during the past thirteen years, has, with almost feverish haste, pushed to practical completion her railway system across two continents. Through a combination of political and physical conditions the Russian Empire is essentially a land power. It has no colonies over-sea. It is one solid, compact land-mass, and the isolated portions of its sea-front are far separated. Russia's naval forces are necessarily widely scattered—in the Baltic, in the Black Sea, in the Caspian, on the Pacific—and cannot be concentrated. For over sixty years the Dardanelles, affording the only means of egress from the Black Sea, has, by the united policy of Europe, been closed to all warships except those of Turkey. To any power thus situated, the "iron horse" is the chief reliance for commercial and political advancement, just as to a maritime nation—that is, to one such as Great Britain or Japan, having scattered possessions and dependent

PASSENGER STATION AT OMSK.

for its life-blood upon foreign commerce—sea-power is the chief sinew of strength and a navy the first line of defense.

It took Russia long to awake to a recognition of this fact. Like all great bodies, she is characterized by great inertia; but, like them, also, when set in motion, Russia—to use a trite metaphor—advances with the irresistible momentum of a glacier toward her appointed end, counting as obstacles neither time, nor tradition, nor the obligations of gratitude, nor the amenities of international courtesy or honor. In addition to being inspired with the Pan-Slavic idea that all other nations, especially those of the West, are decadent, effete, and corrupt; that the Slav is the hope of the future and shall one day rule the world, Russia has long been actuated by the ambition to secure a permanently open seaboard—one with a port ice-free the year round—as an outlet for her commerce. That this ambition is not unreasonable for a nation of such vast territory and resources, and that its realization will probably be a blessing to mankind at large, is coming to be recognized constructively even by those powers that have traditionally fought the Russian claims and blocked the Russian path. As long ago as 1896, Mr. Balfour, the present British premier, then First Lord of the Treasury, in a speech at Bristol, said:

PRINCE M. I. KHILKOV,
Russian Minister of Ways of Communication.

> "So far from regarding with fear and jealousy a commercial outlet for Russia in the Pacific Ocean, which would not be ice-bound half the year, I should welcome such a result as a distinct advance in this far-distant region."

And about the same time, the late Lord Salisbury publicly stigmatized as an antiquated prejudice the notion that there was any essential hostility of feeling or policy between England and Russia. Since then the policy of Great Britain has confined itself chiefly to the securing of commercial and strategical advantages which would compensate for those granted to her rivals, and which would secure some kind of "open door" for world-commerce even in the newly acquired possessions of those rivals, and at the same time preserve the balance of power. In the essentials of this policy, Great Britain has had the active but in-

BRIDGE OVER THE OBI RIVER.

BRIDGE OVER THE IRTISH RIVER AT OMSK.

dependent co-operation of the United States, which in 1899 secured from Great Britain, Germany, Italy, and Japan, as well as Russia and France, a formal acceptance of the principle of the "open door" or "equality of opportunity" for all. In view of these facts, apart altogether from its strategic value to Russia —which may or may not have been the primary consideration in the project—the construction of the Trans-Siberian railway was an economic necessity from the standpoint of world-interests.

It was only, however, when shut out by the concerted determination of Europe from all advance in the direction of the Balkans and the Mediterranean, that Russia turned her eyes eastward, and, as an essential step in internal development and toward the goal of her aims on the Indian and Pacific seaboards, devoted herself strenuously to the extension of her railway communications. Marvelous results have been achieved within the past few years in Central Asia east and southeast of the Caspian, the Russian advance in that quarter now reaching to within striking distance of the British Indian frontier. Still more marvelous, however, as a feat of railroad construction, has been the building of the great imperial road which connects on the Ural frontier with the lines of European Russia and now affords unbroken railway communication between the Pacific coast and the capitals of Europe.

In the Far East, the immediate political exigencies that arose as insuperable obstacles to the Russian advance in Southeastern Europe have been to a large extent absent. Hence it is that the powers have watched with a greater than wonted complacency, though with some misgivings of anxiety, the gradual encroachment of Russia upon the integrity of China. And hence their declared intention to remain neutral in the present war. The atmosphere, however, is electric with apprehension; and it is quite within the range of possibility that the clouds which have spread the Muscovite shadow over Northeastern Asia to the peril of Japanese interests, will not be finally dispelled without imperiling also the peace of the world. On whichever of the two standards victory in the present combat may ultimately rest—even should Russia, by the sheer force of her preponderating mass, succeed by a gradual process of attrition in wearing out her more nimble foe—the interests of other powers will not be neglected in the final compromise. Russia may have to learn again the lesson of San Stefano,

FIRST-CLASS SALOON, TRANS-SIBERIAN RAILWAY TRAIN.

and the ultimate adjustment of matters in the Orient will in all probability be determined by counsels that emanate not alone from St. Petersburg or Tokio.

As for China, her fate has long been practically settled. No formal partition may be made; the outward semblance of imperial sovereignty may remain; but already its substance has disappeared, and the Celestial Empire, venerable with the dust of prehistoric ages, has at last come under the virtual suzerainty of overshadowing powers, which, by the peaceful methods of commercial intercourse and philanthropic endeavor, may awaken new life in her effete civilization without necessarily coming into armed collision with one another.

In view of the present crisis, in the precipitation of which it has been so important a factor, the following summary of descriptive details regarding the Trans-Siberian railway will not be without interest:

Like all the Russian railways, the Trans-Siberian line was built and is operated by the imperial authorities. The first stone was laid at the Pacific terminal of Vladivostok, May 12, 1891, by the then Czarowitz, now Emperor Nicholas II.; and in November, 1901, the laying of the last rail on the Manchurian division completed, with the exception of a 48-mile gap still filled by steam ferry service across Lake Baikal, an all-rail route from St. Petersburg to Vladivostok and Port Arthur, a distance of about 6,500 miles, or twice that between New York and San Francisco. The line is thus by far the longest in the world. It was built entirely by Russian engineers, in this respect marking a contrast to the conditions prevailing a couple of generations ago, when almost all responsible positions in the empire were committed to men from the universities, laboratories, engineering works, etc., of Great Britain or America.

KOREAN WORKMEN EMPLOYED ON THE RAILWAY.

As long ago as 1854, two Scotchmen proposed the construction of a line from St. Petersburg to Okhotsk; and in 1857 an American named Collins suggested the building of a road from Irkutsk, just west of Lake Baikal, to Chita, the emporium of Russo-Chinese overland trade, at the head of navigation on the Amur river. There were other English proposals, but all were laid aside, though Anglo-Saxon brains undoubtedly contributed much of the original stimulus that has since effected such important results.

VIEW OF IRKUTSK.
Near the Western shore of Lake Baikal.

The Trans-Siberian system proper covers about 3,600 miles in Russian and 1,600 miles in Chinese territory, the concession for the latter construction being granted by China in return for Russian diplomatic and financial help in settling the issues arising out of the late war with Japan. The rapidity of construction of the Canadian Pacific Railway, averaging 300 miles annually for ten years, is often cited as marvelous; but of this Russian line 5,166 miles was built in ten and a half years, or at the rate of nearly 500 miles a year. Moreover, a change of plan to secure a firmer roadbed and safer and more adequate service necessitated reconstruction after a considerable portion of the line had been completed. The rapidity of construction is explained to some extent by the fact that work was carried on simultaneously on as many as seven different divisions. Regular traffic on certain sections began in 1896, and in 1899 the number of passengers annually carried had increased to 1,075,000, while the freight forwarded amounted to about 700,000 tons.

When the section around Lake Baikal is completed, the time of passage from St. Petersburg to Port Arthur or Vladivostok will, it is expected, be reduced to twelve or fifteen days, instead of the forty-five days required by the Suez Canal route, or the thirty-five days viâ New York, San Francisco, and the Pacific Ocean. Freight trains now cover the distance from Moscow to Vladivostok in fifty to sixty days, at about eight miles an hour. Their speed will be increased, it is hoped, to thirteen and one-half miles an hour, the present rate of passenger trains.

The road is, on the whole, substantially built. The five-foot gauge conforms to that of the Russian European system; and, as on the western lines of the United States, the road is single-tracked and gravel-ballasted. The stations, which in neatness and in the comfort of their appointments are comparable to the best rural stations in America, present a great variety of picturesque and artistic beauty, no two being exactly alike in style. All sections of the road are carefully tended by guards, who live with their families in neat cottages scattered along the line at frequent intervals.

Bridges are very numerous, steel and substantial masonry being the materials of construction chiefly used. Siberia being a land of mighty rivers with countless tributaries, the problems of bridge construction proved very formidable, and some of these structures rank among the most magnificent in the world, the unrivaled bridge over the Irtish at Omsk, for example, having an opening of 700 yards, and, with its approaches, being nearly four miles long. The Yenisei, the grandest river of Siberia, is crossed by a bridge 1,000 yards in length, while the structure spanning the Amur at Khabarovka is nearly 1,700 yards long. Between Omsk and Irkutsk, the tributaries of the Obi are crossed by forty bridges, each over 200 feet in length. Between Cheliabinsk, on the Ural frontier, and Vladivostok, the aggregate length of the water-crossings, not including Lake Baikal, reaches a total of more than thirty miles. Though skirting the southernmost portions of Siberia,

BRIDGE OVER THE YENISEI RIVER.

where the climate as compared with conditions farther north is delightfully mild, the erection of many hundreds of miles of snow sheds and fences has been necessary to insure the working of the road during the winter season.

TYPES FROM THE STEPPE BORDERLAND.
A Kirgiz Deputation.

The Trans-Siberian system proper may be said to begin at Cheliabinsk, a little town lying amongst the low and pretty Ural hills—hills that have been dignified with the name of mountains, but which serve only to emphasize rather than break the continuity of the European and Asiatic land formation. Unlike the roads in European Russia, whose layout was dominated by military ideals in almost total disregard of existing natural facilities for engineering (as, for example, on the almost perfectly straight reach of 600 miles between St. Petersburg and Moscow), the location of the route through Siberia was determined to a large extent by commercial considerations and a regard for the difficulties of the engineer. There are, however, several extraordinary tangents to be noted, one of these, located in the western section not far beyond the Urals, extending for eighty miles in a perfectly straight line.

Of the various sections, the western is that of the greatest agricultural possibilities. Here the road runs for 600 miles through an excellent farming country producing all kinds of grain in abundance, and for 300 miles through a fine, well-watered grazing region; while for 200 miles east of the Obi the surface of the country, though broken by hills, is heavily timbered and is drained by many small streams. The central division, between Tomsk and Irkutsk, traverses on the whole a barren upland of unknown mineral possibilities, but whose climate and soil are alike forbidding to settlement.

The most formidable engineering obstacles have been encountered in the region around Lake Baikal. This mysterious basin, covering an area of over 13,400 square miles—the only fresh-water sea in the world inhabited by seals—lies at an altitude of 1,500 feet above the sea, but penetrates to a depth of nearly 3,800 feet below sea-level. It is hemmed in by mountains, lofty and forest-clad. Stupendous difficulties are involved in skirting around its southern end, and these have delayed the completion of the railway at this point. Where the shores are rocky, they are seamed by innumerable torrents that have to be bridged; and where flat, they are very marshy.

BRIDGE OVER THE USSURI RIVER.

East of the lake, the road ascends

PASSENGER STATION AT VLADIVOSTOK.

gradually to the crest of the Yablonoi mountains, attaining its highest elevation (3,412 feet), and thence descends the Pacific slope to the valley of the Amur. This Trans-Baikalian section traverses one of the wildest and most romantic tracts ever penetrated by railroad engineers, a section of untold wealth in gold, silver, copper, and iron, which is already attracting a rapidly growing population. The Amur division as projected has its route for about 1,600 miles through well-timbered alluvial land, enjoying a climate tempered by proximity to the Pacific; while the Ussuri section, extending up the valley of the river of that name, from its junction with the Amur at the point where the latter turns abruptly northward on its final rush to the sea, runs through a hilly country well adapted to agriculture and stock-raising and rich in bituminous coal.

The original plans for the Amur route were revolutionized by political developments, and the eastern portion of the Trans-Siberian system reaches the Pacific seaboard at several points by traversing Chinese territory, as already noted, to Niu-chwang, Port Arthur, and Vladivostok. These branches through Manchuria tap a rich and thickly settled farming country.

As bearing on the problem of internal development of Siberia, the railway derives its chief importance from the fact that it establishes regular communication between the rivers, which in that country have been the main arteries of commerce. In the case of all the great streams—the Obi, Yenisei, Lena, and Amur—the crossing is made over their upper waters at about the point where they begin to be easily navigable, in this way facilitating communication throughout the entire length of their valleys. This is of special importance as bearing on the movement of cereals, for over one-half of the present total exports of Siberia consist of these products of the soil, the average annual crop ranging from 3,300,000 to over 4,000,000 tons. The facilities of communication offered by the road will also stimulate development of the arable plains and the cattle-breeding districts of the Steppes now roamed by the Kirgiz race, the finest of the Tartars. For Siberia has the largest grazing reaches in the world and is the original home of the whole graminivorous stock. The road will also render available the wealth of the illimitable forest belt that stretches like a girdle across the continent south of the inhospitable, frozen region of the tundras. And, perhaps of even greater importance, it will hasten the already rapid exploitation of mineral wealth.

The railway has already done much to stimulate the colonization of Siberia and will help toward the improvement of the social and physical conditions of its people. In this way it may be expected to relieve the European provinces of one of their chronic troubles—an unevenness in distribution of population which perennially exposes large parts of European Russia to the hardships of semi-starvation and is a fertile source of pestilence and political disaffection. Every immigrant to Siberia coming with the proper authorization receives a grant of 40.5 acres. During the first three years of residence he pays no taxes; and for the three following years, only half the legal rate. Those without resources are furnished money for transportation, etc. Wood is furnished directly from the imperial forests, and, where this is not possible, can be obtained by settlers at first cost, at certain depots established for the purpose.

LONG-DISTANCE TRANSMISSION OF POWER

A DISCUSSION OF ITS PRESENT ATTAINMENTS AND FUTURE POSSIBILITIES

By Henri F. Chadwick, S. B.

President of the Casino Technical Night School, Pittsburg, Pa.

LONG-DISTANCE transmission of power is a thing of the present. The first practical test of long-distance transmission was given at Frankfort, Germany, about twelve years ago, and since then the advance has been very rapid. All developments in power transmission have been made within the past thirty years, for it was only about twenty-eight years ago that the first practical dynamo was built. From that time to the present, the applications of electricity to various distances has been tried successfully.

In 1890 it was determined to test the possibility of transmitting power from Lauffen to Frankfort, a distance of 110 miles, by use of the polyphase system. Of the complete success of this undertaking, all who have studied electrical matters are informed. This experiment marked an epoch in the commercial development of electricity, for it demonstrated the utility of high voltages in the transmission of power, and also the success of polyphase currents.

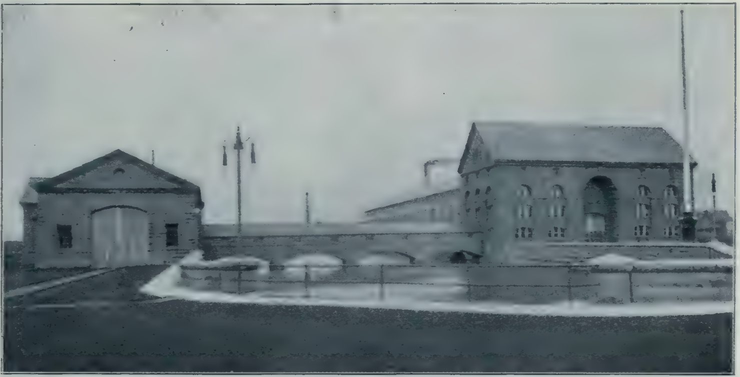
It has since been shown that, considered from an engineering standpoint, there is practically no limit to the distance to which electricity can be transmitted. The only consideration is an economic one. If the location of a place is such that water power is not directly available, and there is great demand for power for which a high price can be paid, then it will be profitable to transmit over a long distance. Power at the present time has been transmitted up to 150 miles with profit. In mining localities it has made possible the extraction of low-grade ores which could never have been mined profitably had steam been the only power available, owing to the great cost of coal.

Before the introduction of electrical transmission, it was possible to distribute energy to short distances by various methods; but no system offered a long-distance transmission for all purposes. By means of dynamo-electric machines, energy obtained from either coal or water power may be transformed into electrical energy; it may then be distributed and again transformed into light, heat, or mechanical power. The limits to the distance of this distribution are determined only by the conditions of economy and safety.

The first long-distance transmission plant was operated by continuous currents, for the simple reason that polyphase currents were then unknown. The continuous-current system has some advantages, but these are more than offset by its disadvantages. The great advantages of this system lie in its small cost for copper, and in the absence of induction effects. Considering the relative cost of copper in the line for a given amount of power transmitted and for a given maximum potential between the conductors, we have the following comparison:

Continuous-current		100
Single-phase alternating		200
Two-phase	"	200
Three-phase	"	150

Thus we see that under the conditions given, there is a great economy of copper in the continuous-current system.



POWER AND TRANSFORMER HOUSES, NIAGARA FALLS POWER COMPANY.

High voltages, however, are necessary for long-distance transmission. These high voltages would make it impossible, without reduction in the voltage, to distribute the power at the receiving end. With a continuous current, reduction of voltage can be accomplished only by using a rotary cummutator of some kind. As this is of course very objectionable, it makes the use of continuous currents practically impossible. The great advantage of the alternating-current system is that the voltage can be changed without the use of rotating apparatus. A low-voltage machine may be used, the current being transformed to one of high voltage for transmission purposes, and then distributed again at low voltage by means of transformers. The great difficulty in this system lies in the fact that the inductance of the circuit causes the current to lag behind the electromotive force. This decreases the amount of energy transmitted by a given current at a given voltage, and it also causes a drop in voltage along the line. The inductance of the circuit can in some measure be compensated for by the use of condensers or synchronous motors. Theoretical considerations show that the influence of capacity upon long, aërial, bare conductors used for the transmission of energy to a distance by alternating currents is, under proper conditions, of so entirely subordinate a magnitude that it need not be considered in the designing of electrical transmission.

The distribution of electrical energy from the generating plant to the lamps, etc., in a circuit, would seem at first glance to be a simple matter; but in fact the problems involved are of great scientific and technical interest. The designing and laying out of a system of conductors to maintain a practically constant pressure over a large area requires engineering skill of no small order. In long-distance transmission the cost of the conductors is almost always larger than the entire cost of the remainder of the plant.

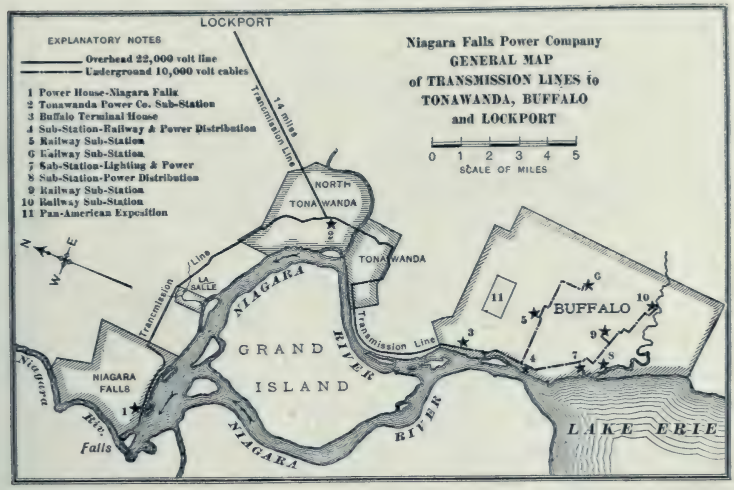
The three-phase system is cheaper for long-distance transmission than one using either single-phase or two-phase currents. Continuous currents are the cheapest of all, but, as already said, are useless for very high pressures. The selection of a system for long-distance transmission of power will depend mainly upon the maximum voltage. If the pressures are such as can be obtained from continuous-current dynamos, there is no doubt but that the continuous-current system is the cheapest and best. But if extra high voltage is advisable, then the three-phase system will generally prove the cheapest. The motto of the electrical engineer to-day is: *Alternating current for transmission; direct current for local distribution.*

The most notable instances of long-distance transmission up to the present time are found at Niagara Falls and at several points in South Africa and Southern California.

In the largest scheme for the distribution of power ever undertaken, namely, from the Niagara Falls, alternating currents in two phases are used. The first distribution was made in 1895 to works located in the vicinity of the plant of the Power Company, and in November, 1896, power was transmitted to Buffalo, twenty miles away, and successfully applied in the operation of trolley lines. Since that time the "harnessing of Niagara" has made substantial progress, until to-day within the region extending westward to St. Catharine's, Ontario, eastward to Lockport, N. Y., and as far southward as South Buffalo, practically every municipal lighting plant and every street-car motor in use is supplied with power developed at the great cataract by the Niagara Falls Power Company.

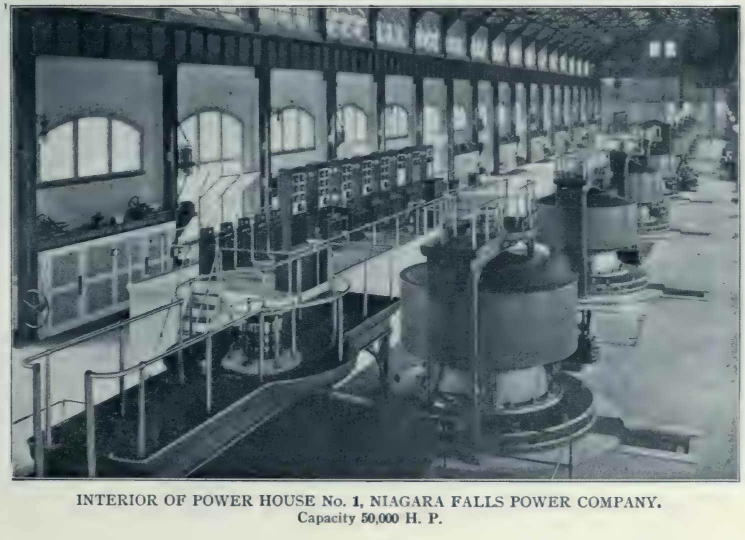
VIEW OF THE AMERICAN FALL AT NIAGARA.

In Africa, it is proposed to harness the Victoria Falls of the Zambesi river. These falls furnish an inexhaustible water power, being nearly a mile in width and 420 feet in height. From the power obtained from these falls, it is proposed to operate the Cape-to-Cairo Railway for a distance of 150 miles, both north and south of the falls; to operate the recently discovered copper deposits,



which lie within 150 miles to the north; to work the coal fields in the vicinity, and eventually to transmit power down to the Rand to work the mines in that now historic district of the Transvaal. It is said that there is practically no limit to the power that can be developed, for even in dry seasons the river is two or three feet deep above the falls and a mile wide.

The climate of Southern California is very favorable for long-distance transmission. The plant at Colgate, located on the North Yuba river, and transmitting power over 150 miles to Oakland, near San Francisco, has been wonderfully successful, and is being widely studied and imitated both in America and abroad. The power house at Colgate has a capacity of 15,000 horse-power, repre-



INTERIOR OF POWER HOUSE No. 1, NIAGARA FALLS POWER COMPANY.
Capacity 50,000 H. P.

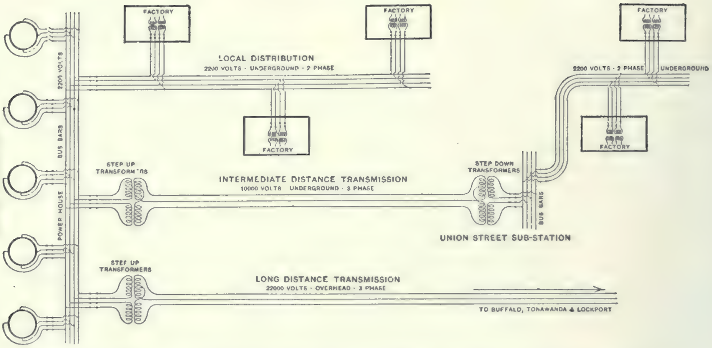


DIAGRAM ILLUSTRATING GENERAL SCHEME OF POWER DISTRIBUTION, NIAGARA FALLS POWER COMPANY.

sented by three generating units of 3,000 horse-power each, and four units of 1,500 horse-power each—seven in all. These dynamos are of the three-phase alternating-current type.

The last century began with Volta and his little battery. The new century starts with the wonderful achievement of the transmission of 80,000 volts over a distance of 200 miles. A few years ago 10,000 volts was the maximum, and was considered difficult to handle. To-day 40,000 is practically standardized, and 60,000 is not unusual. Instead of high voltages being dangerous, they are really safer than moderate voltages, because they are looked on as sources of danger and are carefully installed, being carried over private rights of way and carefully guarded.

Only the imagination can grasp the variety of work which a system like that in California is called upon to do, for it includes all kinds of lighting and every sort of power application, from the running of cars to the operation of flour

SWITCHBOARD IN POWER HOUSE No. 2, NIAGARA FALLS POWER COMPANY.

mills; from the driving of mine stamps to the propulsion of the little sewing machine at work on the making of a bride's trousseau.

The success of long-distance transmission will revolutionize society in the next hundred years. Our cities will be cleaner; large railroad systems will be operated from a central source of supply; waste water powers will be utilized, and there will be a general application of electricity to all kinds of mechanisms and to many social and domestic uses. Long-distance transmission of power is not only an accomplished fact, but has already shown substantial evidences of an effect on business and society that augurs much for the future.

A GRAPHICAL METHOD OF RECORDING DATA OF BOILER TRIALS

By Carl S. Dow, S. B.

Instructor in Mechanical Engineering, American School of Correspondence at Armour Institute of Technology.

THE usual method of keeping the data of a boiler or engine trial is to tabulate the readings. From these readings the results, which are also tabulated—are calculated. To the engineer in charge of the test, these figures are partially satisfactory, but for anyone else to get a good idea of their meaning, careful study is necessary. The tabulated figures give little information regarding the uniformity of conditions during the trial.

To represent the readings and conditions so that anyone interested in the subject can know them at a glance, a graphical record may be made on coördinate paper. This chart has so many advantages that it is well worth the little trouble. For the benefit of those not familiar with graphical representations on coördinate paper, a brief description is here given.

Laying Out the Curves.

The first thing to do is to find out the limits between which the readings are likely to vary. For instance, the steam pressure under working conditions will probably vary not more than ten or fifteen pounds. The engineer in charge of the plant usually knows the limits of feed-water temperature. After noting the

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LOG OF TEST

TIME	COAL		WATER METER	TEMPERATURES		STEAM PRESSURE	DRAFT	QUALITY OF STEAM
				FEED	FLUE			
7.00			226	136	460	86	.47	.97
7.30	7.30	400	267	139	496	91	.49	.98
8.00	8.05	400	304	144	500	91	.50	.97
8.30	8.55	400	337	141	514	92	.52	.965
9.00			379	140	520	93	.52	.97
9.30	9.40	600	422	134	522	91	.51	.99
10.00	10.15	400	491	130	520	91	.52	.98
10.30			534	130	510	90	.53	.97
11.00	10.50	400	564	133	518	91	.52	.98
11.30	11.25	200	610	140	520	92	.54	.98
12.00	12.00	400	640	142	480	91	.53	.98
12.30			650	140	470	90	.48	.98
1.00	1.05	600	672	142	496	86	.50	.99
1.30	1.30	400	723	136	510	90	.53	.99
2.00	2.15	400	763	150	520	91	.54	.98
2.30	2.35	400	810	152	536	93	.53	.98
3.00			850	150	536	91	.52	.98

variations of all the items, the limits may be laid off on the edge of the ruled paper.

The scale to which the readings are plotted depends upon the item. It is quite evident that the feed-water temperature curve should be plotted to a *larger* scale than the curve of flue temperatures. A little thought and calculation will easily settle these points.

As an example, let us consider the accompanying table and Fig. 1. The table shows the readings taken during a certain boiler test recently, and the curves of Fig. 1 form the graphical record of the readings. The readings are given up to 3 o'clock only, as these are sufficient to show the method.

Of course, the layout varies with each test and the scales may be chosen to suit conditions. In Fig. 1, each small division (vertical) represents the following increments:

Temperature of flue gas	20°
Temperature of feed water	5°
Steam pressure	2 pounds
Draft (inches of water)	.05 inch
Calorimeter (quality of steam)	.01
Water	20 cub. ft.
Coal	200 pounds

Time is plotted along the horizontal as shown. It will be noted that all the readings except those of the amounts of coal were taken at half-hour intervals.

After determining the starting-points, it is an easy matter to plot the curves. Let us take the flue temperature as an illustration. From 7 o'clock to 8 o'clock, the temperature rises 40 degrees (500—460=40), and, as one division equals 20 degrees (see table above), the curve rises two divisions as shown. At 9 o'clock the reading is 520 degrees, hence the curve rises one division. By remembering the scales, each reading may be plotted as soon as taken. It is usually easier to plot the increase or decrease from the last reading; but if this is done, the plotted points should be verified occasionally by referring to the base-line of the curve in question.

For plotting the curves, the coördinate paper may be tacked on a board and kept in some convenient place so that each observer may plot his readings immediately after taking them. This is advantageous in that each observer need remember only his own scale and plot his own curve; but it may cause confusion, especially if there are many observers. If there is a sufficient number of observers, one may have charge of the plotting and either go around and get the observations, or the readings may be brought to him to plot and record as a duplicate table.

The reading and plotting of pressures and temperatures will present no difficulty, because they can be taken at stated intervals and the variation is slight. The coal and water, however, are not so easily taken care of. In the case of hand firing, the coal may be weighed and supplied to the floor in front of the boiler in 200-pound lots. Or, all the coal for the test (as nearly as it is possible to estimate it) may be weighed at the start. If the readings are to be plotted, it is well to supply the coal in 200-pound lots

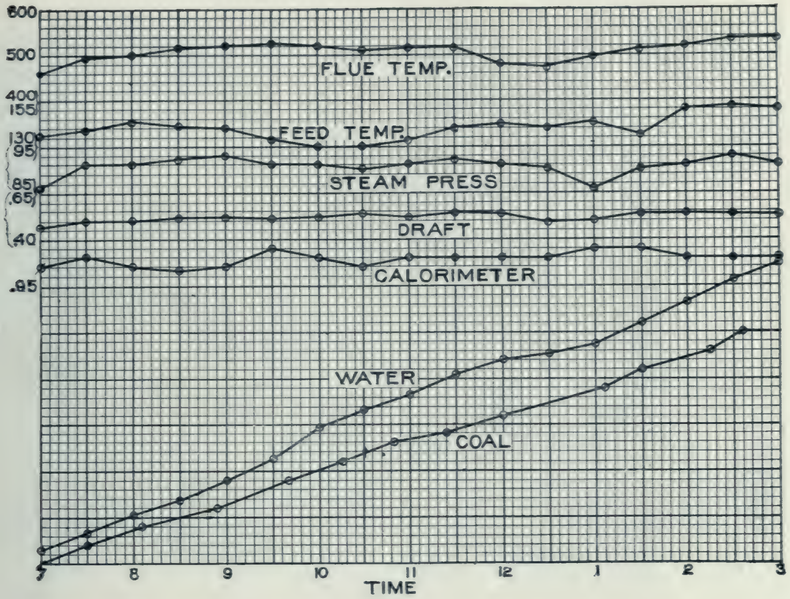


FIG 1

as needed. If the amount of coal kept in front of the furnaces is very slight, that is, if the 200-pound lots are recorded only at the time of firing, the curve showing the amount of coal used will be quite satisfactory.

As before stated, the item of coal consumed cannot be recorded at regular intervals. As the squared paper (see Fig. 1) allows ten spaces per hour, each space is the equivalent of six minutes; and by remembering this scale, the time can be plotted very quickly. Thus, in Fig. 1, the first lot of coal was fired at 7:30, the second at 8:05, the third at 8:55, the fourth at 9:40, and so on.

With mechanical stoking, the curve of coal consumption cannot be plotted in this way, because the hoppers are filled whenever necessary and the amount of coal used between any two intervals of time must be estimated. This estimate would be so unreliable that it would be worthless.

To overcome this a speed counter may be attached to the feed mechanism, and the readings taken at the given intervals. When the test is over, the amount of coal used per 100 revolutions of the speed counter is easily found, since the total amount of coal consumed is known, and the number of revolutions is known. In this way a curve may be plotted to show the coal consumption; it would probably be as accurate as for hand firing.

The water fed to the boiler may be measured by a meter, in a tank, in barrels, or by any other convenient method. In Fig. 1, the amounts are in cubic feet as given by the meter. These readings may be plotted as they are, or they may be reduced to pounds by multiplying by a factor which varies with the temperature. This factor will approximate 62.4. If a water meter is used, it should be carefully calibrated so that the error in this item may be reduced to a minimum.

In plotting the coal and water, it would be well to reduce the meter readings to pounds, and then plot both coal and water to the same scale. This, however, is not at all necessary.

It is a well-known fact that many short boiler tests show remarkable results as to evaporative efficiency. The excellence of these results is due largely to an incorrect estimation of the amount of fuel on the grates when starting and stopping. In making a test from a flying start, the condition of the fires is carefully noted at the time the first readings are recorded. This usually occurs just after cleaning or a few minutes after cleaning.

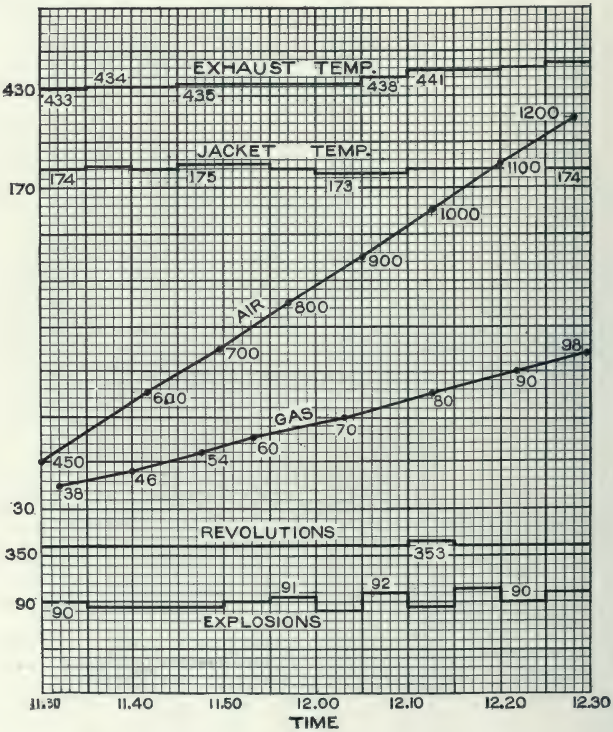


FIG. 2.

To eliminate these starting and stopping errors, the graphical method will be found of great assistance. To do this, the curves should be plotted carefully and then the two ends cut out. As the water level is usually marked at the beginning of the test, careful note should be made at each reading, so that, if the water is above or below normal, the amount may be allowed for.

The curves shown in Fig. 1, are constructed by connecting the points by straight lines. Some prefer to draw a smooth curve through these points.

The graphical method shows inaccuracies in readings, such as counting a lot of coal twice or reading the meter incorrectly. While this is especially true of a test made while running under a steady load, the graphical log is valuable also if the load fluctuates, for the curves for coal and water should show the same relative positions to each other.

Fig. 2 is the graphical log from a test of a small gas engine. It serves to show the application of the same principle to a different test. In addition to the curves shown, the curves for gas used per indicated horse-power per hour may be plotted if there are sufficient observers to measure the cards.

The graphical method is equally valuable in tests of engines and other machinery. With necessary modifications it may be used when testing electrical machinery.

SCIENCE and INDUSTRY

The American Invasion of England

THE *Electrical Times* of London, in a recent issue, contains an amusing editorial on the industrial invasion of England by Americans. It states that the conquest of the world from Maine to Manila is admitted to be the manifest destiny of the United States, and the initial step seems to be the industrial subjugation of Great Britain. On account of the difficulty of distinguishing the invader from a genuine Englishman, opposition is useless. Only recently there was a striking example of the American aggression in the absorption of the Chloride Company of Manchester by the American Storage Battery Company. The annual meeting of the English company was held at Clifton Junction, and Mr. Herbert Lloyd of Philadelphia had charge of the meeting. To comply with the dramatic fitness of things, he should have ordered the "Star Spangled Banner" raised over the company's new offices; but he did nothing of the sort. He merely hinted to the congregated stockholders that he was an Englishman by birth, and was returning to the land of his childhood with the experience gathered by twenty years spent in America. The other director, who lives in America, is also a Britisher, and the American company is virtually controlled by Englishmen.

GENERAL HENRY L. ABBOTT, discussing the Panama Canal route, gives the following valuable information:

Panama vs. Nicaragua

The first point for consideration in judging of the merit of a projected canal is the facility of approach for large vessels. Natural harbors do not exist in Nicaragua, but this statement does not fully cover the case. On the Pacific coast, one might be excavated and probably could be maintained at moderate cost, but on the Atlantic coast a never-ending battle with the forces of nature would be inevitable.

The general characteristics of the inland district to be traversed, next demand attention. Central America has long been known as the home of volcanoes. From January 1, 1901, to September 30, 1903, a period of 33 consecutive months, the official records show 39 slight tremors, 73 slight shocks, and 33 strong shocks, the decided movements continuing for 14 minutes 43 seconds. Similar observations made at Panama for the same period show six slight tremors and three slight shocks, the movements continuing for about 10 seconds. Common sense dictates that the canal should not be placed in the region of greatest danger from earthquakes to be found anywhere upon the continent, when a safer and better route exists elsewhere.

In the important matter of natural harbors, the Panama route has met all the requirements of commerce during the four centuries since its discovery. On the Pacific, when the canal reaches deep water, no works of harbor improvement will ever be required. On the Atlantic, the natural depth now meets the needs of ordinary commercial steamers; and when more is required, it may be secured by dredging, without fear of deterioration, since there are no moving sands to be combated.

The merits of the inland route are equally conspicuous. The distance is only about 45 miles from ocean to ocean, or only one-quarter as long as that by way of Nicaragua; and the summit level may be fixed at about 65 feet, or a little more than half that of the more northerly route. The territory traversed by the Panama route is swept by no strong winds, and the proposed curvature is exceptionally favorable as compared with those found in existing ship canals. The average annual rainfall is heavy, ranging from about 140 inches on the Atlantic coast to about 93 inches in the interior, and about 60 inches near the shores of the Pacific. There is, however, a well-defined dry season of fully three months; and, with judicious regulation of the Chagres river, it is claimed that there will never be objectionable currents in any part of the route. The transit from ocean to ocean can be made in a single day without encroaching upon the night, but night passages can be rendered easy and safe by a system of electric lighting, supplied by water power at the two dams on the Chagres. The floods of the river can readily be controlled, and ample provision to meet the low-water requirements of the canal can easily be made. In a word, an excellent canal, well suited to the needs of navigation, can be constructed; there are no technical difficulties that will not yield to the ordinary resources of modern engineering, if judicious measures are adopted in preparing the final plans. It is true that five locks will be required, two to reach the summit level, two to descend, and one to overcome the large tidal oscillation on the Pacific coast; but experience on the Manchester Ship Canal has within recent years demonstrated that they will entail no serious difficulties in navigation.

New Method of Refining Copper

THE Engineering Department of Cornell University, Ithaca, N. Y., has two students, Joseph Schwab of New Orleans, La., and Isaac Baum of Uniontown, Pa., who have recently made a discovery, which, if it be all that it is claimed to be, will undoubtedly revolutionize the present methods of refining copper.

These young discoverers have proved that the temperature at which copper is now purified, and the current which is passed through the refining vats, are not high enough. They have demonstrated that by using a higher temperature and greater current density, the original cost of a refinery will be greatly reduced. They feel quite confident that their method will soon be adopted by all the refiners in this country. On their thesis setting forth their theory, they received the highest mark ever given to a student at Cornell; and Prof. Wilder D. Bancroft, under whom Messrs. Baum and Schwab have been working, intends to translate their treatise into German for the Electro-Chemical Society of Berlin.

The amount of copper refined in this country each year is estimated at about $80,000,000 in value, from which $12,000,000 worth of silver and $4,000,000 worth of gold are recovered. The cost of refining copper by the methods at present in vogue averages about $5.00 a ton; but if the new process proves a success, the cost will be diminished, it is estimated, by at least one-half.

Sewage Purification

ACTING on the fundamental principle that water pollution is an offense for which every city and village is liable to answer, the State Board of Health of Minnesota has adopted rules making sewage purification compulsory for all cities and villages in that state after January 1, 1905. The objection has been raised that such extreme measures are likely to defeat their own ends, but, although the regulations are radical, they should not be considered revolutionary. The purification required is by means of septic tanks, filter beds, or both, as the Board may require; the plans must be approved by the Board; the discharge of untreated sewage into any water in the State is declared a nuisance, punishable as a misdemeanor; and the Board will decide when and where to bring legal action. Every municipality is thus put on the defensive and, after January 1, 1905, may have to show cause why it should not be fined for not having provided a plant for the purification of sewage.

Wireless Service Now Generally Available

ARRANGEMENTS have recently been concluded whereby the Western Union Telegraph Company will undertake, on and after March 1, 1904, the collection and distribution of messages for the marine service of the Marconi Wireless Telegraph Company of America. The Postal Telegraph Cable Company and the Marconi Company have also for some time past been working under an arrangement similar to that concluded with the Western Union Company. The Marconi Company therefore now has working connections with the two great telegraph companies of America, and messages to and from outgoing or incoming steamships may be routed by either the Western Union or the Postal Telegraph Company as the sender may desire.

The Marconi message for transmission to ocean steamers may now be accepted at any telegraph office in the United States or Canada.

Port Tonnage of the World

THE following table, prepared in the Bureau of Statistics of the new Department of Commerce and Labor at Washington, shows the relative rank in tonnage movement of the principal ports of the world. Figures of coastwise trade are not included:

PORT.	YEAR.	ENTERED. TONS.	CLEARED. TONS.
London	1902	10,179,023	7,385,085
New York	1902	8,982,767	8,415,291
Antwerp	1902	8,373,528	8,347,483
Hamburg	1902	7,860,323	7,993,166
Hongkong*	1901	7,383,683	7,340,586
Liverpool	1902	6,843,200	6,314,514
Cardiff	1902	4,688,088	7,868,556
Rotterdam	1901	5,950,445	5,733,763
Singapore†	1901	5,459,032	5,453,999
Marseilles	1902	4,911,784	4,552,088
Tyne ports	1902	3,615,046	4,754,301
Gibraltar	1901	4,171,350	4,159,272

*Exclusive of Chinese junks engaged in foreign trade. The tonnage of these vessels entered and cleared was 1,126,931, and 1,130,279, respectively, in 1901.

†Exclusive of warships, transports, native craft, and vessels under 50 tons, but inclusive of vessels engaged in trade between the Straits Settlements.

New Harbor Works of Rio de Janeiro

MESSRS. C. H. WALKER & COMPANY of London, Eng., have been awarded the contract for the construction of the new harbor works of Rio de Janeiro, the capital of Brazil, work upon which is to be commenced March 31, 1904.

According to the terms of the agreement, a sea wall or quay 11,649 feet in length is to be built, beginning at the naval arsenal and extending westward, and a channel 820 feet wide and from 26 to 33 feet deep is to be dredged. The level of the quay will be 6.6 feet above the highest tides. The levee at most points will be located some distance out from the present sea front, as the harbor wall will not follow the small indentations of the shore, but will be built in straight lines and wide curves. To furnish the material required for filling in certain spaces, a hill will be cut down. Following the system employed by Hersent in the construction of the Escalda quay at Antwerp, Belgium, caissons of compressed air will be used in building the wall.

The contract provides that 1,640 feet of quay and channel must be completed by June 30, 1906; the same amount in 1907; 2,594 feet in 1908; 2,280 feet in 1909; and the remaining 3,280 feet by June 30, 1910. Payments will be made for every 328 feet of quay finished, and the work completed one month will be paid for by the fifteenth of the following month.

It is feared that this undertaking may have as serious an effect upon the sanitary conditions of Rio de Janeiro as that which accompanied the building of the first levee in Buenos Ayres thirty years ago, and similar constructions in the city of Santos a few years ago. The mortality in both of these cities was terribly increased during the progress of the work.

Forest Conservation in Europe

A SUBJECT now engaging the attention of economists and officials in almost every country of Europe, is the protection of the forests. Laws for that purpose have been enacted by several of the European governments. In Sweden, for example, the new law compels owners of forests to follow a regular system of forest protection. Hundreds of thousands of acres from which all the trees have been cut, are to be reforested, and plans for cutting timber are required to be submitted to a committee having the conservation of the forests in charge. While this law may seem stringent to the property owners, it had become necessary to take some steps to prevent destruction of the forests. In Germany, as stated in a valuable report on the subject of forestry in that country, a gradual but distinct increase in forest lands is shown, and the efforts of the authorities to secure from the forests the best financial and economic results are meeting with marked success.

Discovery of Tin in the Transvaal

A RECENT issue of the *British South African Export Gazette* contains an account of the discovery of tin in the Transvaal, which has aroused much interest in Johannesburg. Experts believe that the colony will be found to be as rich in tin and copper as in gold. The tin-bearing veins are located on the eastern border of the Transvaal, and it is stated that the underlying foundation of the whole district is granite. Above the granite, in some places, uplifted schistose rocks are found, and the veins of tin occur between the schists and the granite. Three lodes have already been discovered. A sample from one of them, when tested, showed 3.5 per cent of white metal, indicating a value of $22.50 per ton. The property is being surveyed by the Railway Department of the Transvaal Government with a view to the construction of a branch line whereby the mineral could easily be brought to Delagoa Bay and thence shipped to England at slight expense. One of the advantages of the present discovery lies in the fact that the mines can be worked very cheaply owing to the mineral being found near the surface.

FACTS OF INTEREST ABOUT RUSSIA AND JAPAN

RUSSIA is in some respects one of the foremost nations of Europe. It is the greatest example in history of a mass of civilizations and barbarisms welded together into a compact political whole. Fifty years ago Japan was referred to as a heathen country, and yet there are certain contrasts which show a higher condition of what we call civilization in Japan than we find in Russia. The Empire of the Mikado is the only Asiatic country enjoying a constitutional form of government.

Russia has a population of 130,000,000; Japan a population of 47,000,000; yet Japan has 4,302,623 children in elementary schools, while Russia has only 4,193,594. That is to say, in Japan 91 children in every 1,000, and in Russia only 32 children in every 1,000, are in the elementary schools.

In the secondary schools and universities also, the proportion is in favor of the Japanese.

Again, Japan has 4,832 postoffices, or one to every 9,700 people, while Russia has only 6,029, or one to every 21,500 people.

Japan's purchases from the United States amount to about $21,000,000 annually; Russia's to only $17,000,000. It seems rather strange that in education, in such an important branch of government as the postal service, and in merchandise, Russia, a nation that has been in direct contact with the civilization of the world for 200 years, should be so far behind Japan, whose intercourse with civilized nations dates no farther back than 1854. Japan has made three times the progress that Russia has in the last fifty years.

GREAT TECHNICAL SCHOOLS

II.—LEHIGH UNIVERSITY

By N. M. Emery, Registrar

SITUATED in the midst of a large park at the base of South Mountain in South Bethlehem, Pa., and surrounded by terraced lawns and noble forest trees, are the ivy-covered buildings of Lehigh University, an institution which owes its origin to the genius of the late Judge Asa Packer, of Mauch Chunk, Pa.

From young manhood Mr. Packer was connected with various business enterprises of the valley of the Lehigh river, including the development of extensive coal lands. With that rare sagacity which characterized him in all his undertakings, he saw that unless these vast stores could be brought to business centers where they could be distributed, an immense amount of wealth would lie dormant and the development of a large section of Pennsylvania would be retarded. Boldly grappling with this problem, he constructed that monument to his business discernment—together with the University most intimately connected with his name—the Lehigh Valley Railroad.

Mr. Packer had not had the advantages of a college education, and fully realized what a help such a training would have been to him in his business and technical undertakings. There was, moreover, at about the middle of the nineteenth century,a great call for skilled men, especially those systematically instructed in the sciences and technology, to help develop the vast mineral resources of the Lehigh valley, in which Judge Packer was financially interested. Fully realizing the needs of the time and of the section, he resolved to devote a part of his wealth to the establishment of an institution for the intellectual development of the young men of the valley, to fit them for the various technical professions.

Accordingly, in 1865, he set aside for the establishment of the University $500,000 and fifty-six acres of land in South Bethlehem, Pa. The University park was subsequently enlarged by a further gift of fifty-two acres from Judge Packer and of seven acres from Charles Brodhead, Esq., of Bethlehem, the area of the University grounds being thereby increased to 115 acres. By the provision of his will, Judge Packer left to the University—which owed its existence entirely to his efforts—a permanent endowment fund of $1,500,000 for general expenses, and $500,000 as a special endowment for the maintenance and growth of the library. He thus devoted to the University, including the cost of the grounds and of the buildings erected during his lifetime, more than $3,000,000—up to that time, it is thought, the largest sum ever given by an individual for the endowment of a college.

In the fall of 1866, after the institution had been duly incorporated by the Legislature of Pennsylvania with the right to confer the various college degrees, work was formally started with a faculty of seven and with two classes numbering forty students. From that beginning the University has gradually grown during the thirty-eight years of its existence, until at present (March, 1904) the teaching force numbers fifty-five and the student body 624, the largest registration in its history.

In pursuance of the purpose of the founder to provide an institution for the training of young men along all branches of activity, technological as well as literary, the University offers various four-year courses: two in general literature—the Classical and the Latin-Scientific; and eleven in technology and science—Civil, Mechanical, Mining, Metallurgical, Electrical, Chemical, and Marine Engineering, Electro-metallurgy, Chemistry, Physics, and Geology, all leading to appropriate degrees.

VIEW IN UNIVERSITY PARK, CAMPUS OF LEHIGH UNIVERSITY.

For pursuing the work of these courses the University is well provided with suitable buildings, laboratories, apparatus, and general equipment. Packer Hall, a four-story sandstone structure, 215 feet long and 65 feet wide, with a tower at the western extremity 200 feet high, built in the English Gothic style of architecture, and located on the upper terrace of the park, thereby commanding an extensive view of the surrounding country, is devoted largely to instruction in the department of Civil Engineering. In the basement of this building are testing laboratories for cement, brick, and metals, which contain 20,000,- 100,000,- and 150,000-pound machines for tension, compression, and flexure tests, a 50,000-inch-pound machine for torsion tests, and special apparatus for experimental work to accompany instruction in strength of materials. The Instrument rooms of the Civil Engineering department are well equipped with transits, levels, and accessories for practical instruction in surveying.

To the east of Packer Hall is the Library, a semicircular sandstone and granite building with a handsome Venetian façade, erected by Judge Packer in 1877 at a cost of $100,000. In the interior, the center is occupied as a reading space, 50 by 40 feet, from which radiate book cases, extending from floor to ceiling, two galleries affording access to the upper cases. The library now has upon its shelves 119,000 volumes, including many extremely rare and valuable books, and there is still shelf room for 50,000 volumes. Especially valuable for professional students is the technical library, numbering over 10,000 volumes, of the late Hon. Eckley B. Coxe, who was for many years a trustee of the University.

Below the Library is situated the Chemical Laboratory, a fireproof building over 200 feet long and nearly 50 feet wide, with a wing, one-half the size of the main building, devoted to the departments of Mineralogy and Metallurgy. In this building the department of Chemistry has large, well-lighted and well-ventilated laboratories for qualitative, quantitative, organic, physiological, agricultural, sanitary, and industrial chemistry, photography, microscopy, gas analysis, and assaying. The Metallurgical department has in this building its offices and lecture and recitation rooms; a blowpipe laboratory for class instruction in both qualitative and quantitative blowpipe analysis and in the practical determination of crystals and minerals; a museum for mineralogical and metallurgical collections; a mineralogical laboratory provided with goniometers, polariscopes and polarizing microscopes; a dry laboratory provided with furnaces for solid fuel and for gas with natural draught and with blast; a wet laboratory for ordinary analytical work; and electric current for electro-metallurgical experiments and reductions. These laboratories are arranged for the instruction of classes in the courses in mineralogy, metallurgy, and blowpipe analysis of the regular curriculum, and to afford facilities for advanced students in conducting original investigations in these departments of science.

PACKER HALL.

The main building of Lehigh University.
Devoted largely to the Department of Civil Engineering.

Further east, close by the central heating plant and connected with it, is the Steam Engineering Laboratory, a new two-story building, 90 by 44 feet, devoted to the experimental study of the accessories of Mechanical Engineering. It is divided into two sections, one for boilers and the other for engines. The former can accommodate three 100-horse-power high-pressure boilers, and the latter the various steam motors and their accessories. In this experimental power plant are contained a triple-expansion engine; a tandem-compound marine engine; a high-speed Ball engine, coupled to a 25-K. W. generator; an air compressor which is compound at both air and steam ends, with reheating and cooling devices attached; and a steam turbine combined with a centrifugal pump. The accessories are several steam, circulating, and air pumps; feed-water heaters; steam separators; box-coil condensers; surface condensers; complete air-brake apparatus, including the pump and engineer's valve; water meters, weighing tanks, and dynamometers for measuring the steam consumption and the development of power. Students in several of the technical courses of the University receive practical instruction in this phase of engineering.

The latest addition to the buildings of Lehigh University is Williams Hall, erected in 1903. This building is 186 feet long by 70 feet wide, and covers a ground area of over 12,000 square feet. One half of the building is devoted to the department of Mechanical Engineering, and the other half to Geology, Biology, and Mining Engineering. In the eastern end are located the recitation rooms, offices, drawing rooms, reference library, and store-rooms of the department of Mechanical Engineering; and in the basement are provided rooms and apparatus for laboratory work in experimental mechanics and engineering physics, such as the calibration of measuring instruments used in Mechanical Engineering, the determination of the mechanical efficiencies of hoisting and other gear, and the testing of motors and other prime movers than steam engines. In this section there are four-cycle and two-cycle gas engines, hot-air pumping engines, electric motors, centrifugal pumps, hoists, blocks, jacks, and dynamometers of all kinds.

In the west end of Williams Hall the department of Geology has its lecture rooms, library, and laboratory of petrology. The department is well equipped with valuable study collections of fossils, rocks, and economic minerals gathered from the type regions in different parts of the world, together with twelve high-grade petrographic microscopes, an apparatus for cutting thin sections of rocks, and field equipment for practical work in the subject.

THE LIBRARY, LEHIGH UNIVERSITY.

The department of Mining Engineering, also with its headquarters in Williams Hall, is well equipped with mining transits, having top and side telescopes and solar attachment, levels, and other accessory instruments for practical work in mine surveying; together with samples of apparatus used in mining operations, drawings, and models of mining plants.

Situated in the extreme northeastern corner of the University grounds is the four-story Laboratory of Physics and of Electrical Engineering, 240 by 50 feet. The building is well furnished with standard apparatus for class-room instruction and laboratory investigation in all branches of physics; also with direct-current and alternating-current dynamos and motors of various kinds, transformers, and a variety of measuring instruments including voltmeters, ammeters, wattmeters, rheostats, contact makers, dynamometers, and condensers—in short, with all appliances necessary for thorough instruction in Electrical Engineering.

Close by the eastern entrance to the University grounds are two brick buildings, Saucon Hall and Christmas Hall. Saucon Hall is used for instruction in English, Economics, and Politics. Christmas Hall, the oldest building in the University Park, contains the drawing rooms of the Mining and Metallurgical Engineering departments, and, in addition, a supply bureau conducted by students of the University, the Y. M. C. A. rooms, and a large reading room and study rooms for students.

THE CHEMICAL LABORATORY, LEHIGH UNIVERSITY.

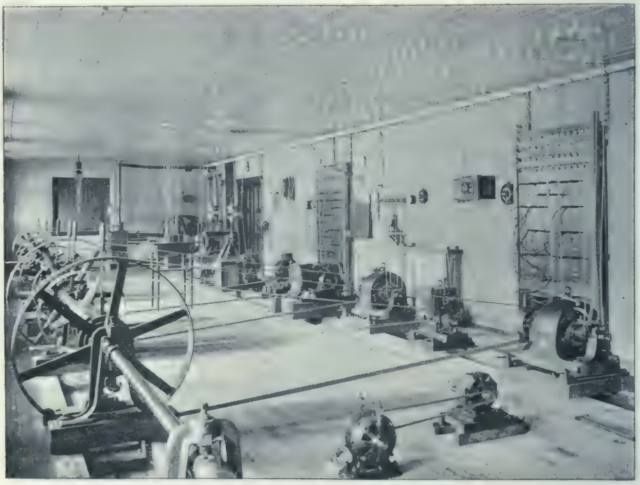
Instruction in practical astronomy is given at the Sayre Observatory, erected and equipped by Robert H. Sayre, Esq., of South Bethlehem, who was a business associate of Judge Packer and who has been a trustee of the University from its foundation to the present time. In this building there are equatorial and zenith telescopes and accessories usually found in well-equipped observatories.

In ministering to the mind, the development of the body is not overlooked, as is witnessed by the Gymnasium, furnished with the best patterns of apparatus for physical culture; and the large Athletic Field, suitably arranged for baseball, football, lacrosse, and all divisions of track and field sports.

Besides the residence of the President and two professors' houses, the remaining buildings in the Park—one of the most imposing structures of all is the Packer Memorial Church, the munificent gift of Mrs. Mary Packer Cummings, daughter of the founder of the University. This edifice, situated near the entrance to the grounds, is one of the largest and most magnificent churches in the State of Pennsylvania. Morning prayers, at which attendance is required of students at least three mornings of the week, are held in this building.

The literary courses of the University —the Classical and the Latin-Scientific— leading to the degree of Bachelor of Arts, are designed to provide general liberal education as distinct from special or professional training. The purpose is to prepare young men for intelligent and successful activity in business, industrial, or professional life. A limited amount of work in subjects which are accepted instruments of general education and necessary preliminaries of all professional study—such as ancient and modern languages, mathematics, physics, chemistry, economics, and psychology—is required of every student in these academic courses. Beyond these subjects, the student is allowed wide freedom in the choice of his work, as the elective privilege extends to all subjects taught in the University. A student is thereby enabled to choose his work systematically with constant reference to his ultimate aims, and, in many cases, may reduce by a year or two the length of his purely professional course. For example, a graduate of either of the academic courses at Lehigh University, who has made suitable electives, can complete in two years the work of any of the courses in technology or science and receive the appropriate engineering degree. Such a broad course, representing liberal training as well as special technical work, makes for professional superiority and success.

The technical courses of the University occupy four years each. During the Freshman year and part of the Sophomore year, several subjects—such as mathematics, English, German, drawing, physics, and chemistry—are common to all courses; and with them are combined elementary engineering subjects. During the last two years of each course, the subjects pursued are almost entirely professional in their character and bear directly upon the special division of engineering or science indicated by the name of the course. Drafting and laboratory practice accompany all subjects capable of being thus illustrated. Visits of inspection are made to the various engineering structures of the vicinity; and practical tests are made by the students of the efficiency of boilers, dynamos, etc., of local manufacturing plants.



CORNER OF DYNAMO ROOM, LABORATORY OF PHYSICS, LEHIGH UNIVERSITY.

Every student is required, as a necessary portion of his final examination, to present a thesis upon some topic connected with the course in which he is to be graduated. This thesis embraces work of independent research under the direction and supervision of the head of the department in which the student takes his degree, and serves as a test of the student's ability to conduct original investigations.

The several departmental engineering societies, conducted by the students of the various courses, form an attractive and valuable feature of college life, and supplement class-room instruction. At the monthly meetings the students read and discuss papers relating to engineering subjects of their particular departments.

Prizes amounting in value to $775 for special proficiency in various departments, are annually distributed on Commencement Day.

Lehigh University is not an *old* college, but its alumni number 1,304, of whom 1,227 are living. The University takes pride in the fact that all of its alumni are employed in influential and remunerative positions, and that the demand for its graduates is vastly greater than the supply. In addition to the alumni, over 1,300 students have taken partial courses at the University but have not been graduated. Thus, with the student body at present enjoying the privileges of the University, more than 3,000 persons have been directly benefited as a result of the far-sightedness and the munificence of a man who was not merely a railroad builder and a capitalist, but as well a true philanthropist.

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EXHIBIT OF THE

AMERICAN SCHOOL OF CORRESPONDENCE

AT THE ST. LOUIS EXPOSITION

ONE of the greatest of our American expositions—commemorating the historic Louisiana Purchase of 1803, and illustrating the marvelous development of our country along all lines during the past one hundred years—will hold its opening exercises in St. Louis, Missouri, about May 1. The nations of the world will bring the products of their genius in science, art, invention, and industry to witness to the wonders of the age in which we live.

The largest and the most imposing of the many beautiful buildings on the Fair grounds is that devoted to Electricity. In this building, the American School of Correspondence will have its display. The space assigned to the School is 16 by 24 feet. The architectural features of the exhibit are designed by Professor Gardner of the Massachusetts Institute of Technology.

Among the many interesting objects in the School's exhibit will be a motor-generator prepared specially for exhibition purposes; two storage batteries to illustrate the instruction paper by Professor Crocker of Columbia University; many interesting patterns, etc., the work of our students. On the rear wall will be placed a 12-foot map of the world, showing the distribution of students, surrounded by enlarged photographs of students.

The May number of THE TECHNICAL WORLD will contain a further description of the exhibit, and illustrations of the architectural designs of Professor Gardner. Thousands of American School students are certain to visit the Exposition during the summer. We extend through these columns a hearty invitation to them to make the School's exhibit their headquarters. Pepresentatives from the School will always be in attendance to assist in any manner our visiting students.

ENGINEERING NOTES

MISCELLANEOUS ITEMS OF INTEREST GATHERED FROM THE TECHNICAL FIELD

CONVERTIBLE PARLOR AND SLEEPING CARS

CARS of this description will be operated by the Holland Palace Car Company of Indianapolis, Indiana. The intention of the company was to build a single car and use it for exhibition purposes, but there came an immediate demand for two cars to be put in practical service, and these were built at the plant of the Harlan & Hollingsworth Company, Wilmington, Delaware, under the direction of the Holland Company's mechanical engineer, Mr. Mason Rickert.

It is not the purpose of the Holland Company to place these cars upon the market, but, instead, to operate them for electric roads in the same manner as sleeping cars are operated for the various steam roads, the Holland Company to own all the cars. The cars of this type thus far built are named the "Theodore" and the "Francis." These will be operated at night as compartment sleeping cars.

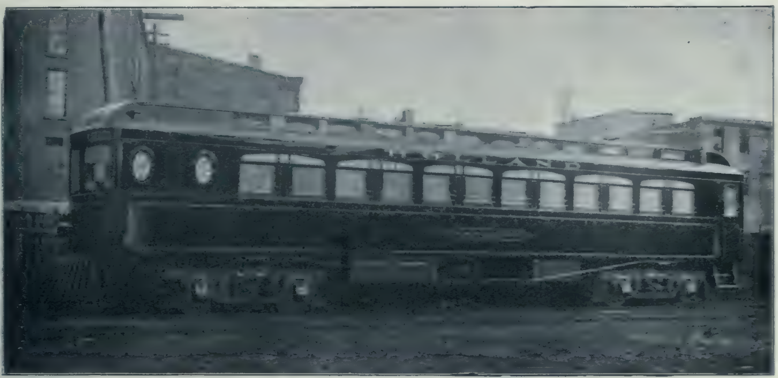
They are 56 feet 4 inches long over all, and are furnished with their own motors, the Westinghouse type being used. Each car has four 150-horse-power motors, making 600 horse-power per car, and geared for a speed of 65 or 75 miles per hour.

The main body of the car is heated by the Peter Smith Heater Company's system of hot-water heating, the motorman's cab being heated by three of the Consolidated Car Heating Company's electric heaters.

The compartments, ten to each car, are located on both sides of a center aisle, each compartment being 6 feet 10 inches long by 3 feet 6 inches wide. There are one lower and one upper berth in each compartment, each berth being 27 inches wide (regular steamer size), allowing a 15-inch dressing space between berth and aisle. The partition that forms the compartment is similar in material and in principle of operation to the cover of a roll-top desk. It is entirely out of sight in the daytime, which arrangement gives an open parlor car with twenty revolving easy chairs. The inside of the partition is covered with handsome tapestry; the window shades are made of pantasote, with green silk face; and the curtains in the doorways consist of double-faced velour. The combination is very effective and makes an exceedingly handsome compartment. Both hot and cold water are provided for the washstands, the hot water being heated by means of an electric water-heater.

INTERIOR OF HOLLAND CONVERTIBLE CAR.

The principal material used in the interior decoration of the cars consists of inlaid mahogany and bronze. The smoking room and men's toilet are at one end,



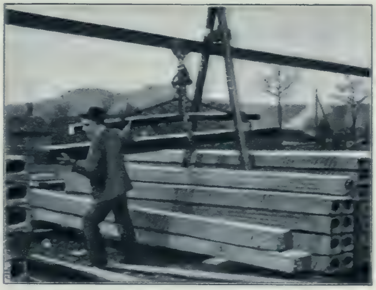
HOLLAND CONVERTIBLE ELECTRIC PARLOR AND SLEEPING CAR.

and the ladies' toilet at the other. The minor equipment includes electric curling irons for the women; electric cigar-lighters in the smoking room; and electric fans at each end in the main body of the car, to be operated during the day.

NEW FLOORING MATERIAL

A NEW system of concrete flooring which will be of interest to builders in the United States, has recently been patented by M. Siegwart, an architect, of Lucerne, Switzerland. It consists of hollow tubes or beams of mortar which are manufactured ready for delivery to the builder. These beams are laid on the supporting walls without planking. By this method, the work of the builder is greatly facilitated, as a number of floors can be laid in a short time by ordinary laborers, and several floors can be used at once for working upon, thus doing away with scaffolding.

Another advantage claimed for the Siegwart system is that beams made in a factory are protected against unfavorable weather conditions, such as frost or rain, during the time the mortar is setting, and it is thus comparatively easy to secure uniformity. The beams made at Lucerne have a uniform breadth of 9.84 inches, and are manufactured in five sizes, 3.5, 4.7, 5.9, 7.08, and 8.36 inches in height, respectively, according to the length of span and load. The size of the iron rods in the beams is between 1.96 and 3.9 inches, and usually six such rods are used in each beam. Two of these rods are laid parallel with the under face of the beam, and the other four are bent upward in the form of a knot at the ends in order to strengthen their supporting power. The proportion of cement to coarse sand used in manufacture is as 1 to 4. The beams, being made hollow, have the same strength as though they were solid, with a great reduction in weight. On account of being hollow, they are more easily heated. Their sides are corrugated so that the cement used in joining them can enter the spaces and form a solid mass.



SIEGWART BEAMS READY FOR SHIPMENT.

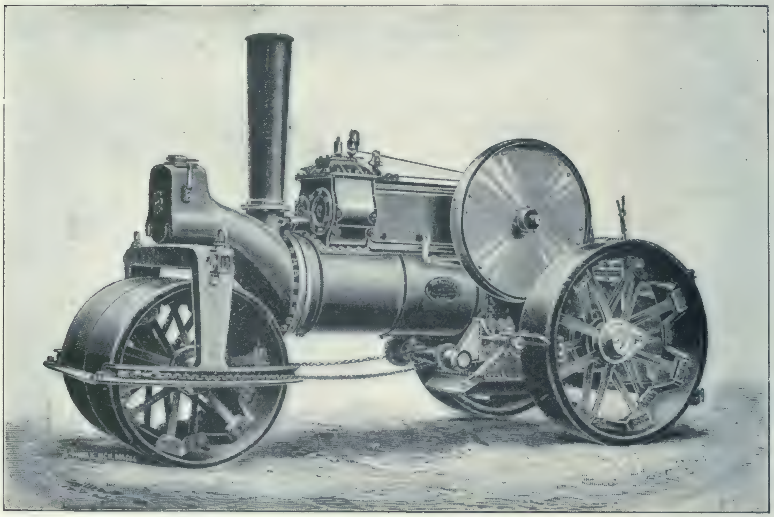
The manner of laying the beams together is exactly the same as in the case of wooden beams. They are made in different lengths, and, besides being used in floors, they can be employed in the construction of roofs, terraces, and staircase supports; also in walls where there is a side pressure, as in warehouses, coal bunkers, etc. It has been demonstrated that these beams can support a load four or five times as great as can the ordinary wooden beams.

The process of manufacture is very simple as carried on at the Siegwart Beam Factory in Lucerne and in other European centers. The beams are made not singly, but in layers 8 feet in breadth. The hollow spaces are formed by means of iron moulds, around which the cement is laid and the iron rods placed in position. The moulds are so constructed that by the turning of a screw they can be reduced in size, and thus easily withdrawn when the cement hardens. Before the cement has set, the beams are cut by a patent cutting machine.

The chief advantages claimed for these beams are: Great supporting power and security from fire; being dry and hard before they are shipped from the factory, the beams can be at once used as floors for working upon; greater ease and speed in building are secured by their use; they insure freedom from excess of heat and cold, on account of their hollow form; the requisite thickness of floors is reduced; and, finally, the beams can be used as a heating floor, by sending warm air through them.

A GERMAN ROAD LOCOMOTIVE

THE road locomotive already occupies an important place in European armies, and is destined to become even more valuable in the future, for by its use it is possible within a very short time to change completely the base of supplies of an advancing army. For transporting heavy siege guns across country, for moving machinery of balloon detachments and iron or steel targets from place to place, and for use as engines to drive dynamos, threshing machines, plows, etc., road locomotives have been found of great usefulness.



A GERMAN STEAM ROAD-ROLLER.

In 1899 the English Government ordered a large number of road locomotives from the firm of John Fowler & Company of Magdeburg, Germany, for use in the Boer war. The heavy guns of the

English warships were often brought into action to support the regular field artillery, and it was impossible to move such guns across the broken veldt with teams of oxen.

The practical utility of such locomotives to pioneers in a new country has been demonstrated for the operation of plows, harrows, discs, rollers, and drawing and ditching machines. These locomotives may also be used on farms, for pulling down trees and hauling heavy loads of lumber.

The steam road-roller used in Germany for making excellent highways is very similar to the road locomotive. The illustration shows the latest steam road-roller with compound cylinders, now in use throughout Germany. This machine may be employed also as a traction engine, and, by means of pulleys, can at any time be used to drive stone-crushers for road-making. The tires of both the front and back rollers are removable, and can be readily changed, thus obviating long stoppages of work for repairs.

APPARENT DISTORTION IN PERSPECTIVE

AN EXPLANATION OF A DIFFICULTY THAT SOMETIMES PROVES TROUBLESOME TO BEGINNERS

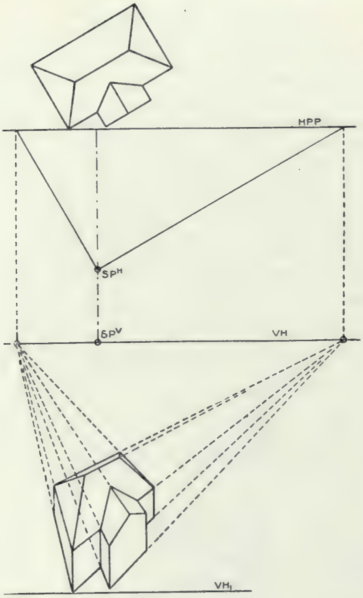
SOME beginners in the study of perpective think that the drawing of an object made in accordance ance with geometrical rules may differ essentially from the actual appearance of the object. Such an idea is erroneous. The only difference between the appearance of a view in nature and its correctly constructed perspective projection is that the actual view may be looked at from any point, while its perspective representation is the view from a particular point, and from that point only.

For every new position that the observer takes he will see a new view of the object in space, his eye always being at the apex of the cone of visual rays that projects the view he sees.

Before making a perspective drawing, the position of the observer's eye (or "station point") must be decided upon, and the resulting perspective projection will represent the object as seen from this point, and from this point only. In order that the drawing may correctly represent to him the object in space, the observer must place his eye exactly at the assumed position of the station point. If this is not done, the drawing will not appear absolutely correct, and under some conditions will appear much distorted or exaggerated.

Just here lies the defect in the science of perspective. It is the assumption that the observer has but one eye. A drawing is generally seen with two eyes, and the casual observer never thinks of placing his eye in the proper position. Even were he inclined to do so, it would generally be beyond his power, as the position of the station point is seldom shown on the finished drawing.

As an illustration of apparent distortion, consider the perspective projection shown in the accompanying illustration. In order that the perspectives of the vanishing points may fall within the rather narrow limits of the figure, the station point has been assumed very close to the picture plane, the distance from H P P to S P^{H} showing the assumed distance from the paper at which the observer should place his eye in order to obtain a correct view of the perspective projection. This



distance is so short that it is improbable that the observer will place his eye in the proper position when viewing the drawing. Consequently, the perspective projection appears more or less unnatural or distorted. For the sake of experiment, cut a small, round hole one-quarter of an inch in diameter from a piece of cardboard; place it directly in front of S P^V and at a distance from the paper equal to the distance of S P^H from H P P, and then look at the drawing through the hole in the cardboard, closing one eye. The unpleasant appearance of the perspective projection disappears.

Unless the observer's eye is in the proper position while viewing a drawing, the perspective projection may give a very unsatisfactory representation of the object in space.

If the observer's eye is not very far removed from the correct position, the apparent distortion will not be great, and in the majority of cases will be unnoticeable. In assuming the station point, a position should be chosen such that the observer will naturally place his eyes there when viewing the drawing.

As a person naturally holds any object at which he is looking directly in front of his eyes, the first thought in assuming the station point should be to place it so that it will come very nearly in the center of the perspective projection.

Furthermore, the normal eye sees an object most distinctly when about ten inches away; therefore, a good general rule is to make the minimum distance between the station point and the picture plane about ten inches. For a small drawing, this will be about right; but, as the drawing increases in size, the observer naturally holds it farther and farther from him, in order to see the whole without turning his eye too far to the right or left.

Some draftsmen make the distance of the station point equal to the altitude of an equilateral triangle having the extreme dimension of the drawing for its base and the station point for its apex.

The apparent distortion is always greater when the assumed position of the observer's eye is too near than when it is too far away. In the former case, objects do not seem to diminish sufficiently in size as they recede from the eye. On the other hand, if the observer's eye is between the assumed position of the station point and the picture plane, the effect is to make the objects diminish in size somewhat too rapidly as they recede from the eye. This effect is not so easily appreciated nor so disagreeable as the former. Therefore it is better to choose the station point too far away than too near.

Finally, the apparent distortion is more noticeable in curved than in straight lines, and becomes more and more disagreeable as the curve approaches the edge of the drawing. Thus, if curved lines occur, the station point should be chosen with great care; and, if possible, such a view of the object should be shown that the curves will fall near the center of the perspective.

THE FIELD OF CORRESPONDENCE EDUCATION

By FRANK W. GUNSAULUS, D. D.

President Armour Institute of Technology

INSTRUCTION by correspondence has had very much the same battle to fight which came to University Extension work. No method of broadening the beneficent influences of education will ever escape attack from the self-appointed aristocracy of culture. Democracy, however, conquers in the present and has the entire field of the future. As certain as our American life accomplishes its best in the world, so certain will be the broadening, along with the deepening, of American intellectual and spiritual power. Americanism will be trained to the accomplishment of large results, American in their scope, by the triumph of a certain republicanism and democracy in religion and education. Just as the church, to be worthy of her existence, must go to the world and bring it to God, so the school must go to the people and give them all it can impart and all that they will receive.

Every effort of this kind has two perils; and the first and least important is that of which I have already spoken, the criticism of those who gather their academic robes about their precious dignity, insisting that all methods differing from the regular ways and means must be failures. They opposed University Extension and Chautauquas with no avail. The second is the criticism of those who have expected too much and are unwilling to meet half way, with pluck, energy, and devotion, the efforts which are made to enrich their minds and train their powers. This second peril is the only one which now seriously threatens instruction by correspondence. It will always threaten the noblest work of the school as well as the church, for the spirit of it is indolence and insincerity. No church is good enough to save a man who will not offer what goodness he can muster up for the mutual enterprise of his salvation. It is the same with every educational instrumentality. There must be a Garfield at the other end of the bench in order that a Mark Hopkins shall justify his existence and laboriousness.

Much disaster has been wrought by unscientific, and therefore untrue, methods in all education. Correspondence instruction has not escaped. It must proceed on the supposition that its band of learners will be an heroic band. I have never known an equal number of brave and tireless pupils. Their examination papers come in grimy and greasy, and thoroughly mastered. They do their work at times when other men are loafing in the saloon or sleeping. They have found out how to reap a harvest from the fructifying minutes. They form the best temperance society on earth, because no man can keep up his studies and attend to his work in the department in which he is studying to be a better engineer or mechanic, and be a tippler at the same time. It is so with almost all other kinds of instruction by correspondence. We who are engaged in thus taking the results of years of effort and experimentation to the workingmen of the country, are thrilled with the quick and sympathetic response made to every agency we employ to accomplish the result of training American manhood into self-respect and complete power.

Just at the time when America sees that she has not yet opened her most valuable resources at home, she is confronted with a sudden and well-nigh overwhelming gift of opportunity in her new realm abroad. That realm is not, as we know in these days, to be subdued by armies with cannon and sword: it is to be brought safely and loyally in league with our American position by the conquest of ideas and ideals. Among the leaders of such an advance, the engineering student in this our practical age is likely to be foremost.

One of the things most unfortunate either to the development of our American resources, or to the development of engineering as a science, is the fact that

FRANK W. GUNSAULUS, D. D.

President Armour Institute of Technology.
Chairman Advisory Board, American School of Correspondence.

engineering science and practice has been regarded as a field to be entered only by highly trained and favored students. To be masterful in the highest degree in anything is, of course, to be a trained scholar in that thing; but it is simply false to say that the door of entrance is closed. The conceit of pedantry is laughable enough; but it is worse in its effects than we suppose. The current opinion of a few years ago, that a man without certain technical information, difficult to obtain, could be nothing but a hired hand, has done vast harm. It has placed engineering where such a notion would have placed politics, had not the notion been broken to fragments by undeniable facts. Suppose, for example, that the science of politics had been hedged about with as much of academic propriety as has fairly shut out many strong men from intelligent engineering practice. Here comes along a young man with a burning pine knot and a courageous soul, who has a few books and a clear head. His name is Abraham Lincoln. Now the subject of politics is fully as profound and complex as the subject of engineering. This man gets at the essential, and, by going right at the heart of his subject, the poor boy of the cabin rises to be the most amply equipped and comprehensive master of politics in his time. It has often been said that such men as Lincoln have so much genius that schools would make very little difference with them. It is to be replied that just such young men as Lincoln must have the opportunity presented to them, and just such an opportunity must have a Lincoln presented to it, through books or schools—it matters not—in order that, first, we may have full development of our America; second, that we may have the full development of our politics; third, that we may have the full development of our Lincoln.

So of engineering. Every Lincoln demonstrates that there is more to be acquired and used by what is called the unfavored, and often the ordinary man, than we have agreed upon in our philosophy of education. If he be an extraordinary mind, as was Lincoln, born and reared at the bottom of the ladder, so much the more important for the profession which is hobbling along without him, and so much more important for the nation that needs his remarkable power, that he and his powers have brought to them all that can possibly be known and acquired just where he is.

We have missed too many men who were just a little less than strong enough to do without what they should have had. Our educational system has been too much like a pyramid resting upon its apex. To save the cause of republicanism and democracy, it must rest upon its base. Education needs an Edison as badly as the young Edison ever needed education, which at last he attained through great sacrifice.

Instruction by correspondence can never take the place of residence instruction at a great school. But President Harper does not go too far when he says: "Direction and correction may be given oftentimes as effectively by written as by spoken word." One of the most interesting facts about correspondence instruction, especially in engineering, is that the student has his laboratory usually at hand in the very room in which he is working and in the very machinery by the use of which he makes his living. He can make his examinations as frequent as he desires. He will find the instruction papers just as scholarly as they are simple and applicable to his necessities. He will be disappointed just as a man will who goes into a library and does not faithfully use the instruction which is waiting there for him, if he does not meet the educational enterprise with a firm determination and an open mind.

Carlyle's saying that "the true university of these days is a collection of books" never seems so true as when a man has been trained, through correspondence with living instructors, how to use the information conveyed in printed words. Thousands of young men will annually be rescued to the charm and satisfaction of the intellectual life when our foremost seats of learning radiate their light in sympathy with the needs of the American democracy. We can build our pyramid all the higher and let its apex be all the more neighborly to the limitless realms of truth, if that pyramid is broad-based and the whole people of our country feel and know that the educational advantages offered will somehow reach them and bind them, the lowliest to the loftiest.

MATERIALS FOR PATTERNS

A DETAILED DESCRIPTION OF THE KINDS OF WOOD USED, METHODS OF SEASONING, BUILDING UP STOCK, ETC.

As a pattern may be subjected to rough usage, and is alternately wet and dry, the material should be able to withstand the wear and tear of handling, and at the same time be impervious to moisture. Such material is to be found in the metals; but, as the cost of working these into the proper shape is considerable, some kind of wood is usually substituted.

Kinds of Wood Used

If wood is to be used, another qualification is to be added—namely, it should be easily worked. The best wood for the purpose is undoubtedly white pine. Care should be exercised in the inspection of the wood, to see that it is clear, straight-grained, and free from knots.

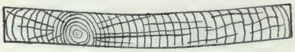


Fig. 1.

The straightness of the grain can be determined by the appearance of the sawn face. This should present an even roughness over the whole surface. The wood should be seasoned in the open air, but preferably sheltered by a roof, and should be piled so that the air will have free access to all parts of the plank. In the natural process of air-drying, the moisture slowly works out to the surface and evaporates until the wood is dry or "seasoned." Such stock is firmer, stronger, more elastic, and less affected by heat and cold and by moisture and dryness, than kiln-dried lumber. In kiln-drying, the outside surfaces and ends of the boards are dried more rapidly than the inside, producing strains that cause the wood to bend and warp while the pattern is in the process of construction. For this reason it is better to "build up" the larger pieces of a pattern by gluing together three or more *(never two)* pieces of thinner stock. When the patterns are of moderate size, the stock to be glued may vary from ⅜ inch to 1 inch or even 1¼ inches in thickness, in proportion to the size required. Stock 2 inches in thickness or over can seldom be found sufficiently seasoned; and, if forced by kiln-drying, it will be checked and strained to an extent that will render it useless for pattern work.

While pine is in general the ideal wood for pattern work, it is soft and weak, so that if small and strong patterns are desired a harder wood is usually employed. Mahogany is much used for this purpose. Like pine, it is not liable to warp, and, when straight-grained, is worked with comparative ease. There are many varieties of this beautiful wood, varying greatly in firmness of texture. The soft bay wood, often sold as genuine mahogany, should be avoided for patterns, being but little harder than pine. Cherry is also extensively used, but is not so easily worked to a smooth surface as mahogany, and is more liable than the latter to warp and to be affected by moisture. Black walnut, beech, and maple are used to some extent. Black walnut is stronger than cherry, but, like beech and maple, is liable to warp.

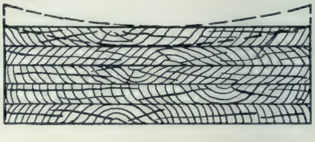


Fig. 2.

It may be stated, then, that in the United States white pine is the material commonly employed for pattern-making. Lumber 1 inch, 1¼ inches, and 1½ inches thick will be found convenient in the construction of most patterns. Much time and labor may be saved if, after the lumber has been carefully selected, it is taken to the planing mill and dressed on two sides to the following thickness:

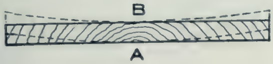


Fig. 3.

1-inch, dressed on two sides to ⅞-inch;
1¼-inch, dressed on two sides to 1⅛-inch;
1½-inch, dressed on two sides to 1⅜-inch;
and, if such can be found well seasoned, a small quantity of 2-inch dressed to 1¾-inch.

In addition to these sizes, there should be a moderate amount of 1-inch resawed and dressed to ⅜-inch or to $^{5}/_{16}$-inch; and the same amount of 1¼-inch resawed and dressed to ½-inch. The two last thicknesses are used for gluing and building up the rims of pulleys, gear wheels, and other light work where strength and durability are required.

Warping and Twisting of Wood

Observation shows that if one side of a board is kept damp and the other dried, the former will expand so that the plank, although originally straight, becomes curved as in Fig. 1. Or if one side of a board is exposed to the air, while the other is more or less protected, as in the stack of boards shown in Fig. 2, the exposed side of the upper board will give off its moisture more rapidly than the other side, and the board will warp or bend in the direction shown by the dotted lines. The second board will also "draw," and to some extent follow the first, being in turn followed by the third, and so on until the entire stack is warped and bent.

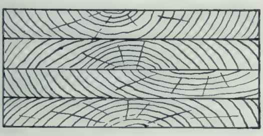


Fig. 4.

The same will be found true of a well-seasoned board, if after being planed it is allowed to lie on its side on the work-bench. The upper side will give off its moisture more freely than the under side, the latter being protected and having its moisture retained by the bench. The lower side of the board expands and the upper contracts, with the result that the board, although originally planed straight, becomes curved. For this reason, all lumber, even if well seasoned, should be so placed in racks or on end that the air may have free access to both sides of the planks; and newly planed boards, however dry and well seasoned, should never be stacked together, but so placed that both sides will be exposed alike.

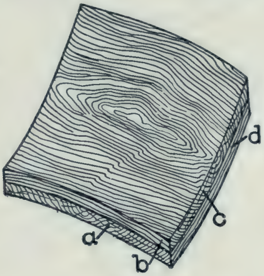


Fig. 5.

This tendency to warp is probably due to the porous nature of all woods, and their inclination to give off or to absorb moisture according to the condition of the surrounding atmosphere. The moisture in the air, and in lumber of all kinds, which is ever changing with the conditions of the surrounding atmosphere, causes a corresponding expansion or contraction of the wood.

Even under cover and in a dry place, wood has a tendency to warp on account of the greater shrinkage of the newer as compared with the older cells of the wood tissue or fiber in the side of the board nearest to the outside or sapwood of the tree. The inner side A of the board (Fig. 3), being closer to the heartwood, is older than the side B; its cells are

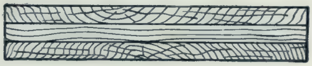


Fig. 6.

firmer and more compact than those of B. As the board seasons, the newer and more open cells of the side B will shrink faster and to a greater extent than those of A, thus causing the board to draw or warp in the direction indicated by the dotted lines.

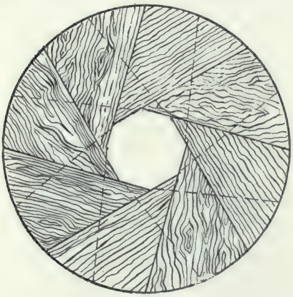


Fig. 7.

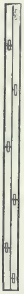


Fig. 8.

In gluing or building up stock for a pattern, this tendency may be corrected to some extent by reversing the grain of the pieces that are to be glued, and placing two outsides (as B, Fig. 3) or two insides (as A, Fig. 3) together. This is illustrated in Fig. 4.

In gluing very thin pieces together for the webs or centers of pulleys and for other purposes, it is often necessary to reverse the grain of the pieces, or to place the grain of one piece at right angles to that of the other, for the purpose of gaining greater strength and stiffness. In such cases, if only two thin pieces are used, the result, after they have been glued and dried, will be to some extent as shown in Fig. 5, the shrinkage and strain of the end grain crosswise of the board at *a* being sufficient to bend the opposing thin board lengthwise of the grain at *b*, while on the side *cd* the curve will be reversed for the same reason. Whenever it is necessary to cross the grain of thin pieces for a pattern, three or more pieces should be used, which will give satisfactory results if placed together as shown in Fig. 6.

When thin circular discs of large size are to be glued up for patterns of any kind, the strongest, stiffest, and most satisfactory results will be obtained if the pieces are fitted and glued tangentially to the hub or other center or opening in the disc, as shown in Fig. 7. The grain of the wood must run lengthwise, and parallel to the longest side of each sector; and, after the pieces have been fitted together, a thin groove is cut in the edge of each, in which thin tongues of wood are inserted and glued, as illustrated in Fig. 8. Two discs are glued up; and one is turned over so as to reverse the grain of the sectors of one disc on that of the other, as shown by the dotted lines. The discs are then glued together, making a very rigid construction, and one which, owing to the continual change in the direction of the grain, will not warp.

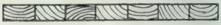


Fig. 9.

Should a wide and thin piece of a single thickness be required for a pattern, the board from which it is to be made should be ripped into strips of two, three, or four inches in width (according to the width of the required board), and the strips glued together again with each alternate strip reversed, as shown in Fig. 9. In this way the tendency to warp is to a great extent corrected, each narrow strip being inclined to warp in an opposite direction to that of its neighbor.

ARCHITECTURAL LETTERING

A DESCRIPTION OF VARIOUS LETTER FORMS SPECIALLY ADAPTED FOR THE PRACTICAL USE OF THE DRAFTSMAN ON PLANS, WORKING DRAWINGS, ETC.

PRACTICALLY all the lettering now used in architectural offices in this country is derived, however remotely it may seem in some cases, from the old Roman capitals as developed and defined during the period of the Italian Renaissance. These Renaissance forms should be studied first at a large size in order to appreciate properly the beauty and the subtlety of their individual proportions. For this purpose it is well to draw out at rather a large scale—four or four and one-half inches in height—a set of these letters of some recognized standard form; and in order to insure an approximately correct result some such method of construction as that shown in Figs. 1 and 2 should be followed. This alphabet, a product of the Renaissance, though of German origin, is one adapted from the well-known letters devised by Albrecht Dürer about 1525, and is here merely redrawn to a simpler constructive method and arranged in a more condensed fashion. This may be accepted as a good general form of Roman capital letter in outline, although it lacks a little of the Italian delicacy of feeling, and thus betrays its German origin.

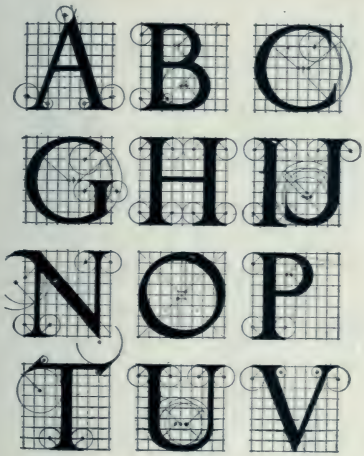


Fig. 1.

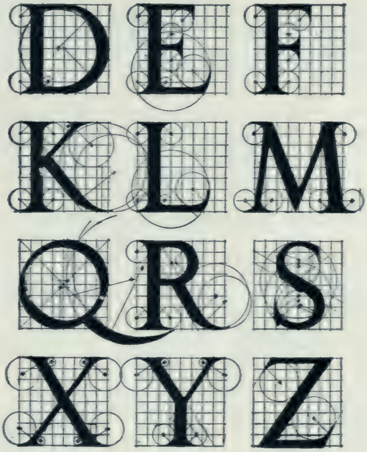


Fig. 1 (Concluded).

The letter is here shown in a complete alphabet, including those letters usually omitted from the Classic or Italian inscriptions: the J, U (the V in its modern form), and two alternative W's, which are separately drawn out in Fig. 2. These three do not properly form part of the Classic alphabet and have come into use only within comparatively modern times. For this reason, in any strictly Classic inscription, the letter I should be used in place of the J, and the

V in place of the U. It is sometimes necessary to use the W in our modern spelling, when the one composed of the double V should always be employed.

The system of construction shown in this alphabet is not exactly the one that Dürer himself devised. The main forms of the letters, as well as their proportions, are very closely copied from the original alphabet, but the construction has been somewhat simplified and some few minor changes made in the letters themselves, tending more towards a modern and more uniform character. The two W's, one showing the construction with the use of the two overlapping letters V, and one showing the W incorporated upon the same square unit that carries the other letters (the latter form being the one used by Dürer himself), are shown separately in Fig. 2. It should be noticed that every letter in the alphabet, except one or two that of necessity lack the requisite width—such as the I and the J—is based upon and fills up the outlines of a square, or, in the case of the round letters, a circle which is contained within the square. This alphabet should be compared with the alphabet in Fig. 4, attributed to Sebastian Serlio, an Italian architect of the sixteenth century. By means of this comparison a very good idea may be obtained of the differences and characteristics that distinguish the Italian and German traits in practically contemporaneous lettering.

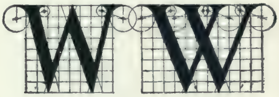


Fig. 2.

After once drawing out these letters at a large size, the beginner may find that he has unconsciously acquired a better constructive feeling for the general proportions of the *individual* letters; and he should thereafter form the letters freehand without the aid of any such scheme of construction, merely referring occasionally to the large chart as a sort of guide or check upon the eye. For this purpose it should be placed conveniently, so that it may be referred to when one is in doubt as to the outline of any individual letter. By following this course and practicing thoroughly the use of the letters in word combinations, a ready command over this important style of letter will eventually be acquired.

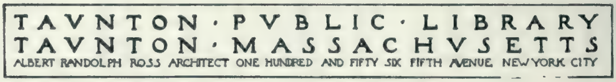

TAVNTON · PVBLIC · LIBRARY
TAVNTON · MASSACHVSETTS
ALBERT RANDOLPH ROSS ARCHITECT ONE HUNDRED AND FIFTY SIX FIFTH AVENUE NEW YORK CITY

Fig. 3.

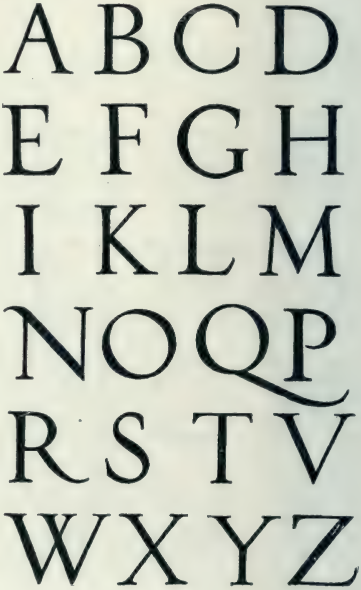


Fig. 4.

In practice it will soon be discovered that a letter in outline and of small size is more difficult to draw than one solidly blacked-in, because the defining outline must be even upon both its edges; and that as the eye follows more the inner side of this line than it does the outer, the inaccuracies of the outer side of the line are likely to show up against the neighboring letters, and produce an irregularity of effect that it is difficult to overcome; while in a solidly blacked-in letter, it is the outline and proportions alone with which the draftsman must concern himself. Therefore, a letter in the same style is more easily and rapidly drawn when solidly blacked-in than as an "open" or outline letter.

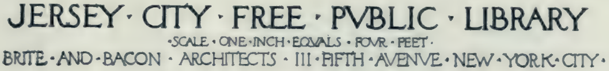

JERSEY·CITY·FREE·PVBLIC·LIBRARY
·SCALE·ONE·INCH·EQVALS·FOVR·FEET·
BRITE·AND·BACON·ARCHITECTS·111·FIFTH·AVENVE·NEW·YORK·CITY·

Fig. 5

In many cases where it is desired to give a more or less formal and still sketchy effect, a letter of the same construction but with certain differences in its characteristics may be used. It should not be so difficult to draw, and much of the same character may still be retained in a form that is much easier to execute. Some such letter as is shown at the top of Fig. 9, or any other personal variation of a similar form such as may be better adapted to the pen of the individual draftsman, would answer this purpose. The titles shown in Figs. 3 and 5 include letters of this same general type, but of essentially different character.

In drawing a letter that is to be incised in stone, it is customary to show, in addition to the outline, a third line about in the center of the space between the outside lines. This additional line represents the internal angle that occurs at the meeting of the two sloping faces used to define the letter. An example is shown in Fig. 7, taken from drawings for a building by McKim, Mead & White, the same convention being frankly employed to emphasize the principal lettering of a pen-drawn title.

For the purpose of devising a letter that may be drawn with one stroke of the pen, and at the same time retain the general character of the larger, more Classic alphabet, in order that it may be consistently used for less important lettering on the same drawing, it is interesting to try the experiment of making a skeleton of the letters in Figs. 1 and 2. This consists in running a single heavy line around in the middle of the strokes that form the outline of these letters. This "skeleton" letter, with a few modifications, will be found to make the best possible capital letter for rapid use on working drawings, etc., and in a larger size it may be used to advantage for titling details. It will also prove to be singularly effective for principal lettering on plans, to give names of rooms, etc., while in a still smaller size it may sometimes be used for notes, although a minuscule or lower-case letter will be found more generally useful for this purpose.

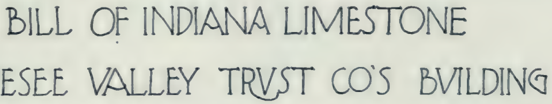

BILL OF INDIANA LIMESTONE
GENESEE VALLEY TRVST CO'S BVILDING

Fig. 8. Title from Architectural Drawing. Claude Fayette Bragdon, Architect.

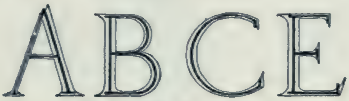


Fig. 6.

In Fig. 6 are shown four letters where the skeleton has been drawn within the outline of the more Classic form. It is unnecessary to continue this experiment at greater length, as the idea is sufficiently developed in these four letters. In addition, it is merely the theoretical part of the experiment that it is desirable to impress upon the draftsman. In practice it will be found advisable to make certain further variations from this "skeleton" in order to obtain the most pleasing effect possible with a single-line letter. But the basic relationship of these two forms will amply indicate the propriety of using them in combination or upon the same drawing.

It will be found that the letter more fully shown in Fig. 9 is almost the same as the letter produced by this "skeleton" method, except that it is more condensed.

That is, the letters are narrower for their height and a little freer or easier in treatment. This means that they can be drawn more rapidly and occupy less space, and also that they will produce a more felicitous effect.

In actual practice, the free capitals shown in Fig. 9 will be found to be of the shape that can be made most rapidly and easily, and this style or some similar letter should be studied and practiced very carefully.

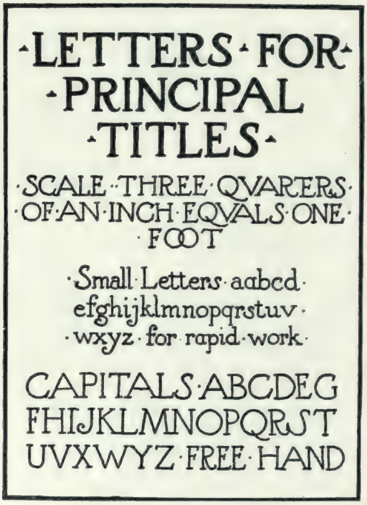


Fig. 9.

Other examples of similar one-line capitals will be found used with Classic outline or blacked-in capitals on drawings, Figs. 3, 5, and 7. In Fig. 8, this one-line letter is used for a principal title as well, and with good effect.

In Fig. 9 is shown a complete alphabet of this single-line letter, and also an excellent form of small letter that may be used with any of these capitals. It is quite as plain as any Engineer's letter, is easier to make, and, when correctly placed upon the drawing, is much more decorative. Fig. 9 represents the actual letter shapes that are used on architectural drawings. As they are so valuable to draftsmen, they should always be at hand for instant use.

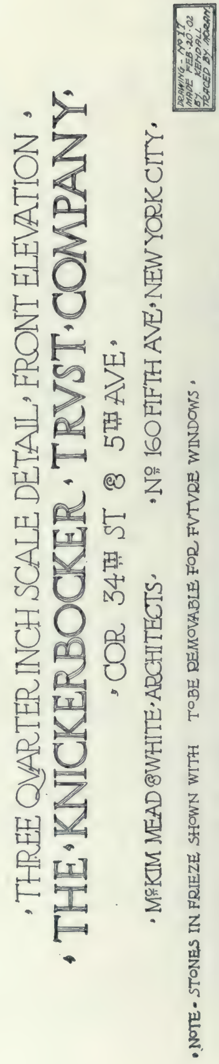

, THREE QVARTER INCH SCALE DETAIL, FRONT ELEVATION,
, THE, KNICKERBOCKER, TRVST, COMPANY,
, COR 34TH ST & 5TH AVE,
, McKIM MEAD & WHITE, ARCHITECTS, , No 160 FIFTH AVE, NEW YORK CITY,
, NOTE - STONES IN FRIEZE SHOWN WITH TO BE REMOVABLE FOR FVTVRE WINDOWS,
DRAWING - No 17
MADE FEB. 20. 02
BY. KENDALL
TRACED BY. MORAN

Fig. 7. Title from Drawing of Building for the Knickerbocker Trust Co., New York. McKim, Mead & White, Architects.

THE VALUE OF A TECHNICAL EDUCATION

BASED ON THE OBSERVATIONS OF A PRACTICAL ENGINEER AS TO THE COMPARATIVE EARNING POWERS OF THE TECHNICAL SCHOOL GRADUATE AND THE APPRENTICE OR THE GRADUATE OF THE TRADE SCHOOL

WHATEVER may be said for or against the value of a university training for a man who is to enter business, there is no question of the value of systematic schooling to one who proposes to enter some department of mechanics.

It is true that there have been unusually brilliant men who have reached the highest position in their profession without the theoretical training which is now given in first-class technical schools. These men, however, are the exception and not the rule.

Before the founding of technical schools in America, mechanical and civil engineers were obliged to go to France or Germany to study their profession, or stay at home and learn in what was called a "practical" way by their own experience, by the observance of certain rules and formulæ, or by doing as they were told.

These so-called practical men knew little or nothing of the great principles underlying their profession, and consequently had little ability to go out of the beaten track. They were never certain that if innovations were made they would be of a safe character.

With the introduction of technical schools in this country, some thirty years ago, the work of mechanics took on a new phase. Guesswork began to be eliminated, and accurate knowledge took its place. The so-called practical workers were left in the field, but each year sees them superseded by men who have had a thorough technical training in a school devoted exclusively to that purpose.

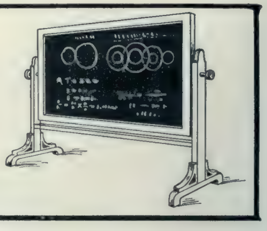
The power which the trained mechanic or engineer has at his command over that of the untrained, is hardly to be estimated. The latter finds himself handicapped at every new turn of affairs. What is outside of his past experience becomes a perplexity, and he must appeal to someone to help him out of the difficulty. On the other hand, the man who has a knowledge of the principles on which mechanics are based can adapt those principles to the ever-changing conditions, and know exactly whether his work is right or wrong.

The value in dollars and cents of the trained workman over the untrained has lately been investigated by James M. Dodge, president of the American Society of Mechanical Engineers. He finds that a graduate of a high-class technical school earns less the first year of work than the apprentice or the graduate of a trade school. In a short time he passes the apprentice, and in three years he is on a par with the graduate of the trade school, but with vastly greater prospects of advancement. Then his earning power over the latter begins and continues to increase yearly, so that at the age of thirty his potential value is immensely greater.

It would seem, then, that a technical school is the best investment of time and money for one who intends to enter upon any mechanical profession. The advantage is so widely recognized now that before long there will be little chance in the higher lines of mechanical work for any but thoroughly trained men.—Chicago *Chronicle.*

CHALK TALKS

by CARL S. DOW



II.—CAPACITY OF TANKS

TO find the number of gallons in a tank of given dimensions is a common problem among sheet-metal workers, plumbers, and all those engaged in mechanical work. This problem is solved by finding the volume in cubic feet, and then reducing to gallons.

Tanks are made in a variety of shapes, but most of them are either rectangular or cylindrical. In the rectangular tank, the top, the bottom, and all the sides are rectangles. In the case of the cylindrical tank, the base is a circle; and the tank may be vertical, as shown on the blackboard, or it may be horizontal. In either position, the volume is the same.

Let us illustrate the principles by calculating the number of gallons in these two forms, each tank having given dimensions.

Rectangular Tank

The rectangular tank shown on the blackboard is 11 feet long, 4½ feet wide, and 4 feet high. We know that the volume of the rectangular tank is equal to the area of the base multiplied by the height.

Area of base $= 11 \times 4\frac{1}{2} = 49\frac{1}{2}$ sq. ft.
Volume $= 49\frac{1}{2} \times 4 = 198$ cub. ft.

Since one cubic foot contains 7.48 gallons, 198 cubic feet will contain $198 \times 7.48 = 1{,}481.+$ gallons. Hence the capacity is 1,481.+ gallons.

Cylindrical Tank

Let us assume the cylindrical tank shown at the right-hand end of the blackboard to be 6½ feet high and to have a circular base 7 feet in diameter. As in the case of the rectangular tank, the volume equals the area of the base multiplied by the height.

The area of a circle is found by multiplying the diameter by itself and by .7854.

Area of base $= 7 \times 7 \times .7854 = 38.485$ sq. ft.
Volume $= 38.485 \times 6\frac{1}{2} = 250.15$ cub. ft.

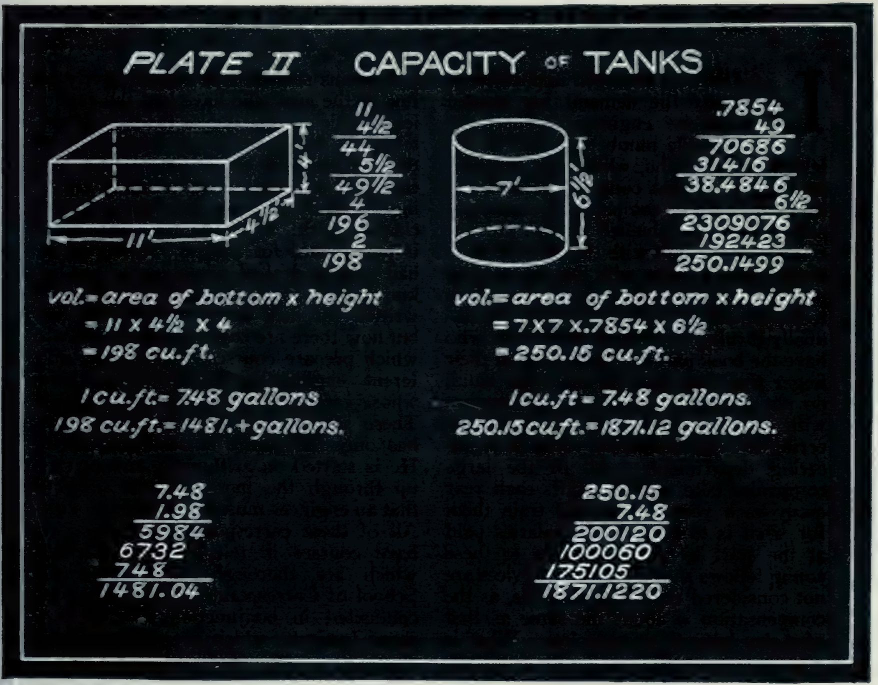
To find the capacity in gallons, we need only multiply by 7.48. This gives us $250.15 \times 7.48 = 1{,}871.12$. Thus we find that the capacity of the cylindrical tank is 1,871.12 gallons.

In addition to the capacity in gallons, it is frequently necessary to know the weight of the water in the tank.

Experiment shows that a gallon of water weighs 8.33 pounds; hence we find the weight by multiplying the capacity in gallons by 8.33.

The weight of water in the rectangular tank equals $1{,}481 \times 8.33 = 12{,}336.73$ pounds.
The weight of water in the cylindrical tank is $1{,}871.12 \times 8.33 = 15{,}586.43$ pounds.

By using these principles, it is easy to find the number of gallons in tanks, and the weight of the water.



DINNER-PAIL PHILOSOPHY

Living costs more in these days—but it is worth more to live.

Most of us have a hard row to hoe, because we dislike hoeing.

A good many things are bad, but the worst never really happens.

Some people die of heart failure, and others live with head failure.

The trouble with the men who pay as they go is they go mighty little.

Lots of marriages call for relief expeditions—from the bride's father later on.

Truth is constantly getting in the way of most people. That is why it is crushed to earth so often.

Signing a document without reading it, often makes a man wish he had read it without signing.

The average get-rich-quick scheme has highway robbery beat to a standstill.

Some men spend lots of time in saloons—and that's about all they do spend.

Don't worry. Perhaps the dollars you did not win are already spent by the fellow who got them.

If you do not think of what you are going to say, you generally say what you were not going to think.

No matter how religious a bald-headed bachelor may be, married women are always suspicious of him.

A young man often stays up nights to learn things that give an old man insomnia trying to forget them.

A man may or may not think it a compliment to have a brand of cigars named after him. It all depends on the cigars.

THE DEMAND FOR TELEPHONE ENGINEERS

LATELY it has been impossible to supply the demand for trained telephone engineers. There are an ample number of men in the telephone field, who, while their practical training is all that could be desired and they are entirely competent to construct and handle the smaller plants, are not conversant enough with the theoretical to enable them to cope with the engineering problems of the larger exchanges. The technical schools over the country are annually turning out bright young men who have the book part of engineering at their finger tips, but who, on the other hand, do not possess a sufficient acquaintance with things as they really are in engineering to be of immediate value in engineering departments. All of the large companies take on their staffs each year many such young men, and train them for what is to come. The salaries paid at the start by the companies to these young fellows show that their services are not considered especially valuable, as the compensation is about the same as that of a day laborer, or even less. What is wanted is a practical man with a theoretical training, and the calls for such men indicate that there are not many who possess these qualities who are not already comfortably settled in some good position.

It seems strange that comparatively so few of the men who have had the experience which would make them excellent telephone engineers avail themselves of the opportunities which men of this day can have of securing the technical training necessary to equip them for a higher class of work. It will be conceded that it is pretty hard for a man who has never had a great deal of schooling, to dig his knowledge from textbooks that were written for men better versed than he; but now there are correspondence schools which prepare courses covering the different engineering branches for those whose early education has been limited. These schools will take a student who has only the ability to read and write. He is started on arithmetic, and carried up through the more difficult subjects that an engineer must be conversant with. All of these correspondence institutions have courses in telephone engineering which are thorough. The American School of Correspondence in Chicago is conducted in conjunction with the Armour Institute, which is an endowed institution, as are other educational institutions of the country, and which is doing much toward the spreading of knowledge and the equipping of telephone men for the field of telephone engineering.—*Telephone Journal.*

* * *

A FARM WORKED BY ELECTRICITY

ONE of the most wonderful farms in the world is situated in Canada. Its peculiarity lies in the fact that everything is worked by electricity. Two waterfalls within the bounds of the farm, about 60 feet and 160 feet high, furnish the motive power, a central power-house being erected near, and the current is transmitted by wires to every available place on the farm. The churns and other necessary implements have electric motor attachments. A motor of 10 horse-power works a mowing machine, and another works a log saw, while the house, barns and grounds of the farm are illuminated by the electric light. The whole farm illustrates natural resources put to the best practical use

A MAN'S LEISURE TIME IS HIS UNUSED CAPITAL

ANY careful reading of the mechanical achievements of the nineteenth century will reveal that our most important inventions had for their primary object the saving of time. It was the desire to lessen the time and labor of weaving that brought the steam-power loom from the brain of Cartwright. To keep up with the intellectual requirements of man, the hand-press of Gutenberg gave place to the fast-running machinery of Nicholson. To supply the world with cloth, the primitive spinning wheel, driven by foot or hand, and winding but a single thread, evolved into Hargreaves's jenny with vertical spindles operating countless threads. To furnish food for the race, the stout arm and scythe of the farmer gave place to the reaping machine. In a similar manner have come the swift-sailing steamship, the express train, the telegraph, the telephone. Give this subject any reasonable investigation, and you will discover that the "time element" has played an exceedingly important part in the development of our twentieth century.

* * * *

One of the most valuable arts the average person can master is the ability to economize time skilfully by avoiding those harmful by-paths that dissipate the odd half-hours that rightly belong to the day of labor. It is one of the verities of history that the world owes less to the men and women of leisure than to any other class. Of course there are a few noble exceptions; but as a general rule, the more leisure men or women have, the less real work you get out of them. The Bishop of London was standing in the door of his home, when a wealthy gentleman approached him and said, "I want your advice, my Lord; how am I to bring up my son so as to make him get forward in the world?" "I know of but one way," replied the Bishop; "give him parts and poverty."

* * * *

Any young person who has an intelligent estimate of his own value will appreciate what may be accomplished in a few minutes. A single half-hour each evening, devoted to the study of any science or language, would enable a man of average ability to master the one or the other in a few years. One half-hour each evening, devoted to study, would make a man of no education intelligently informed on a wide range of important subjects.

* * * *

It would surprise the most of men, if they knew how much of what is most valuable in our civilization we owe to the spare quarter- and half-hours saved by men and women who had a purpose in life and who labored for its perfection. Robert Burns composed many of his sweetest poems while returning from the field after a hard day's work. To an hour each evening, the world owes the steam locomotive of George Stephenson. Grote, the author of one of the standard histories of Greece, was a busy banker, and history was the recreation of his spare moments. Sir John Lubbock became one of the foremost authorities in prehistoric archæology by using the odd half-hours after his work. Hundreds of men and women have risen into prominence and power, not so much from any special genius, but rather by discovering the value of time and making a wise use of it. Promptness in business, in friendship, in recreation, in study, are great virtues. They will enable a youth of average ability to win out, when that unclassified species, the genius, fails.

* * * *

Some time ago a gentleman was in a car on the Madison Avenue line; and, on the upper end of the route, only the conductor and this gentleman remained in the car. The conductor sat down, took out a book, and began reading it at the back end, turning the leaves from right to left. "That must be Hebrew he is reading," the gentleman said to himself. The conductor seemed to be greatly interested in the subject. He nodded his head approvingly, and occasionally chuckled when the author made a good point. Finally, the passenger went over to his side and said, "Excuse me, but are you reading Hebrew?" The conductor nodded. "Are you a college graduate?" Another nod. "What college?" "Yale, '85." Now, the probabilities are that that young man, well equipped as far as scholarship was concerned, filled that humble position from something like the same reason that an old colored man gave, when asked, "How do you pass the time, Uncle?" "Well, Boss," he answered, "I sit down under the shade of this 'ere elm tree and let the time pass me."

"There is a tide in the affairs of men,
Which, taken at the flood, leads on to fortune;
Omitted, all the voyage of their life
Is bound in shallows and in miseries.
On such a full sea are we now afloat,
And we must take the current when it serves,
Or lose our ventures."

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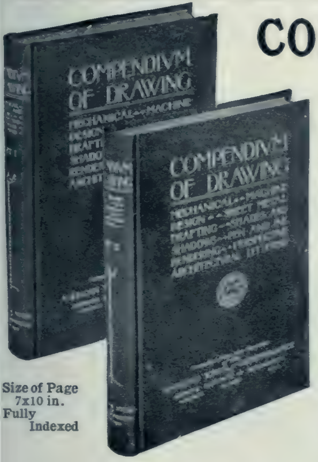
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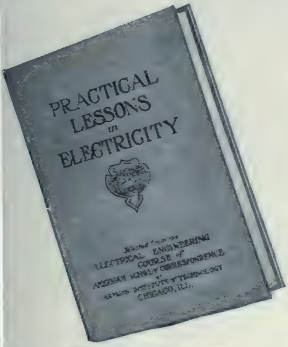
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Rogers. Accordingly, instead of the $2,000 installment which they should have paid Mrs. Rogers at that time, they notified her that the firm intended to continue the manufacture of the goods irrespective of her patents, and defied her to prevent them.

It was then that Mrs. Rogers enlisted the services of Miss King, who, realizing that the suit hinged on a question of equivalents, felt that it would materially help in handling the case if she were an expert engineer as well as a lawyer. To gain this knowledge she took up a course in mechanical-electrical engineering in the American School of Correspondence at Armour Institute of Technology, which she had nearly completed before the time of the final hearing of the suit. The knowledge thus acquired was of great benefit to Miss King in conducting the cross-examination of the expert engineers who were introduced as witnesses on the other side.

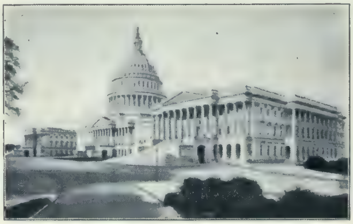
That a woman should master the intricacies of patent law and attain eminence in that branch of jurisprudence which is conceded to be the most abstruse, is in itself a matter worthy of note; but what makes it even more remarkable is the fact that she is entirely self-educated.

Miss King was born in a little log cabin near Waterloo, Iowa, and when only five years of age was left an orphan. She was raised on a farm among humble country folks, and acquired the rudiments of an education in the district school. As a girl, she earned her first money by working in a kitchen for $1.25 a week. Her earliest glimpse of the world beyond her immediate environment was gained when she was summoned to the county seat to appear as a witness in a neighbor's lawsuit. This was a trying ordeal for the shy country girl, but once within the court-room she forgot her fears. The dignity of the judge and the keenness of the opposing lawyers made a deep impression upon her as she watched everything with absorbed interest. Before court adjourned, Florence King had made up her mind to learn shorthand, and this determination was the foundation of her career.

With that firmness of purpose which recognizes no such word as "fail," she worked her way through Mount Morris College, and after graduating with honors, came to Chicago with only $6.00 in her purse. Within a few days she secured a position as stenographer in a publishing house, where she remained until she heard of an opening in a patent lawyer's office. This work was thoroughly congenial, but Miss King was not content to take dictation; she wanted to be a lawyer herself. She began the study of law in a night school, and at the end of two years was graduated in a class of one hundred, ninety-nine of whom were men. After being admitted to the bar in Illinois, she continued her studies and applied for admission successively in the United States Circuit and District Courts, and finally in the Supreme Court of the United States.

There are two maxims which Miss King says have engraved themselves deeply upon her mind:

> *First*—If the opportunity you are looking for does not present itself, create it.
>
> *Second*—In starting anything always be sure you are right then go ahead, and never give up.



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By Harris C. Trow, S. B.

Instructor in Electrical Engineering, American School of Correspondence
at Armour Institute of Technology.

IN order to understand the operation of the telephone, it is necessary, first of all, to understand the principles underlying the production of sound, or of acoustics. Sound is produced by vibrations in the air set up by whatever may be the cause producing the sound. These vibrations strike the eardrum, and the sensation of sound is conveyed to the brain. The pitch depends upon the rapidity of the vibration, the loudness upon the amplitude, and the quality upon the form of the vibration.

The simplest sort of vibration is that set up by a musical tone, and to give an idea of the rapidity of vibrations for a specific case it may be stated that the musical tone known as middle C is set up by 256 vibrations per second. The vibrations set up by the voice in speaking are of a much more complex nature in every way, and on this account the earliest telephones could reproduce musical tones, but could not transmit speech.

The earlier telephones served to transmit and reproduce the vibrations of the voice by means of electro-magnetic induction. A typical telephone circuit in its simplest form is shown in Fig. 1. There are two similar instruments, one at each end of the circuit; we may consider one the transmitter and the other the receiver. M and M_1 are two permanent bar magnets, on the ends of which are coils of fine insulated wire, C and C_1. In front of the magnets are thin elastic discs of sheet iron, D and D_1, commonly known as the diaphragms. Let us consider the left-hand instrument the transmitter, and the other the receiver. The permanent magnet M sets up a certain number of magnetic lines of force through the coil C; and as the diaphragm D offers a path of lower magnetic resistance than the air, many of these lines pass through it. When we speak close to the diaphragm

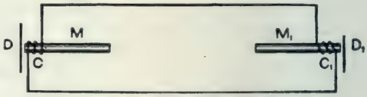

Fig. 1.

Historical Note.—THE TELEPHONE of to-day depends for its operation upon the principles of magnetic induction, so that in tracing its discovery back to its source we find that the first step was taken about 1820, when Oersted discovered the influence of an electric current upon a magnet. A little later, Schweigger constructed a galvanometer; while in the same year, Arago and Davy demonstrated the fact that if a rod of magnetic material be placed within a solenoid carrying current, the rod will become magnetized.

In 1823 Ampere published the results of his experiments along this line. In 1825 Sturgeon constructed the first electro-magnet, which later was improved by Henry. Next, Henry and Faraday set about to find a way of producing an electric current from magnetism, as magnetism had been produced by a current. About 1830, and almost simultaneously, they were successful, and demonstrated the fact that if a magnetic field were produced, or altered, within a coil, a current was produced.

These great physicists and experimenters mentioned were not working toward the production of a telephone although their investigations gave rise to its possibility; and others soon took up the task of applying these fundamental principles to the production of a method of transmitting speech. After many attempts, more or less successful, by different men, each one of which added its share to the development, a practical telephone was invented in 1876 by Alexander Graham Bell and Elisha Gray. The credit is, however, usually ascribed to Bell, as the Patent Office allowed his claim precedence.

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D, the air vibrations cause the diaphragm to vibrate. As it approaches the magnet M, more magnetic lines pass through the diaphragm; and when it recedes, fewer lines pass through it. This action alters the number of magnetic lines which pass through the coil C, and hence alternating currents are induced in it which are proportional in strength to the rate of change of the number of lines.

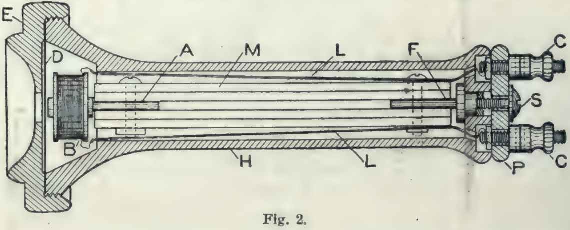

Fig. 2.

These currents also pass through the coil C_1 at the receiving end of the line, and, according to the direction in which they flow around the magnet M_1, alternately add to or tend to neutralize its strength. When the current strengthens the magnet, it causes it to attract its diaphragm D_1; and when the current decreases the strength of the magnet, the diaphragm moves away. In this manner the diaphragm at the receiving end is made to vibrate in exact unison with the one at the transmitting end, and thus similar vibrations of the air are set up, reproducing the sounds spoken into the transmitter.

The above arrangement has been somewhat modified in the telephone of the present day, and it has been found more convenient to have a separate transmitter at each end of the circuit. The transmitters now in use operate on entirely different principles, but the receiver is essentially the same.

Receivers

There are two common forms of receiver: the single-pole and the bipolar type.

A single-pole receiver of the Bell type is shown in section in Fig. 2. It consists of a hard rubber case H, in which is placed the laminated or compound bar magnet of steel M. This magnet is composed of two sets of bars separately magnetized; clamped between them by means of screws is the pole-piece of soft iron A at one end, and the block F at the other end. Upon the pole-piece is placed a coil of fine insulated copper wire B, connection being made from it to the binding-posts C C by means of heavy wires L L. The binding-posts are attached to the end piece P, which is held in place by the screw S, which threads into the block F and thus serves also to keep the magnet in position. The cap E screws to the case and supports the diaphragm D, which is a flexible disc of soft iron. The diaphragm is placed a short distance in front of the pole-piece of the magnet, and the portion directly opposite it is free to vibrate.

This instrument is being supplanted to a great extent by the bipolar receiver, which differs from the single-pole receiver in that the permanent magnet, instead of being straight, is constructed upon the horse-shoe principle. This brings both poles in position to act on the diaphragm, giving increased strength of field, and consequently making the instrument more efficient. A soft-iron pole-piece is secured to each end of the magnet, and a coil of insulated copper wire is mounted on each pole-piece.

At the present time the single-pole receiver is sometimes used for local work, while the bipolar receiver is employed both for this and for long-distance work. There is also another form of receiver known as the watch-case type, which is used to some extent for desk sets and at the exchange switchboard.

Transmitters

The type of telephone just described was originally used as the transmitter as well as the receiver; and for short dis-

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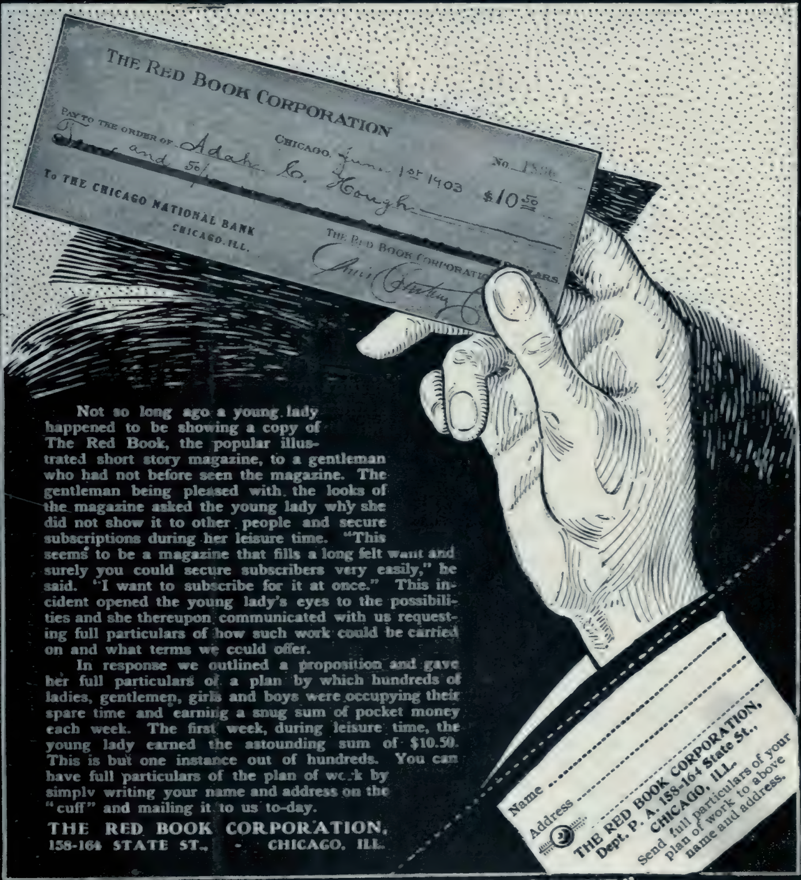

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tances, in which the line resistance was small, it gave fairly good results.

It is now the practice to use this instrument as the receiver only, and to use a different form of instrument, together with a battery, for the transmitter. The action of this transmitter depends upon the fact, that if the resistance of a circuit is increased, the current will be decreased, and if the resistance is decreased, the current will be increased. This variation in resistance is produced by varying the pressure upon one or more carbon contacts. If the pressure is increased, the resistance is decreased; and if the pressure is decreased, the resistance is increased.

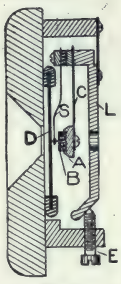

Fig. 3.

There are three types of transmitter: in the first but one carbon contact is used for varying the resistance; in the second several contacts are used; and in the third granular carbon is employed, thus giving a very large number of contacts.

The Blake transmitter, a section of which is shown in Fig. 3, is an example of the first type. This instrument, in common with all other transmitters, has a diaphragm D somewhat similar to that of the receiver. This is supported in a rubber ring, and is held in place by two damping springs not shown in the cut. Mounted upon a light spring S, and resting against the back of the center of this diaphragm, is the front electrode, which is a platinum pin. Directly back of this piece of platinum, a carbon button B, which forms the other electrode, is supported by means of a spring C, so adjusted that the carbon button bears lightly against the platinum pin. The tendency of the spring S is to press the platinum pin away from the diaphragm; but this is overcome by the stiffer spring C, which bears in the opposite direction, and so keeps the platinum in contact with the diaphragm. The electrode B is mounted in a comparatively heavy socket of brass A. Both electrodes can move freely with the vibrations of the diaphragm; but the carbon, on account of the inertia due to the weight of the brass socket, moves more slowly than the other. Any vibration of the diaphragm will, therefore, result in a variation of the pressure between the two electrodes, and thus vary the resistance of the contact.

The two springs S and C are insulated from each other, and the current goes to the contact point by means of one spring and leaves by the other. The adjustment of the pressure is effected by means of the screw E, which bears against the lever L.

This transmitter is quite satisfactory for lines of moderate length, and is used to some extent at the present time. It is, however, somewhat difficult to keep in adjustment, and is not well adapted for long-distance work.

The second type of transmitter mentioned is not much used in this country, and a description need not be given.

The most common form of transmitter, and the one which is rapidly replacing all others, is the Hunnings or granular carbon type. This, as originally planned by its inventor, consists of two insulated plates of conducting material which form the electrodes of the transmitter, the space between them being filled with granular carbon. The general form of this instrument is shown in Fig. 4. D is the diaphragm of metal or carbon, which is clamped between the body of the case C and the cap A by means of screws. Another conducting plate B, of metal or carbon, is placed in the back of the case, and the space between D and B is filled with granular carbon. The conducting plates D and B form the electrodes or terminals of this transmitter. When the diaphragm is spoken against, it of course vibrates, and thus varies the pressure upon the numerous contact points of the granular carbon through which the current must flow to pass from one electrode to the other, and thus the resistance is varied as in the Blake instrument. Larger currents can be used with the Hunnings type of transmitter than with other sorts, and it has the further advantage of allowing a greater variation of resistance.

The transmitter which is used almost entirely at the present time is known as

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the "solid back," being a modification of the Hunnings type just described. The case, which is of metal and hollowed out to contain the working parts of the instrument, is enclosed by a brass cover, which also carries the mouthpiece. The metal diaphragm is supported in a ring of soft rubber attached to the back of the cover. The electrodes are enclosed in a metal chamber which is lined with insulating material. This electrode chamber is secured by means of a set screw to a metal bridge which is attached to the back of the cover by means of screws. Both electrodes are of carbon, being in the form of discs somewhat smaller in diameter than the containing chamber. The space between the electrodes is filled with granular carbon as is also the space between the circumference of the discs and the insulated walls of the chamber. The rear electrode is mounted upon a brass disc which is screwed to the back of the chamber, thereby holding the electrode securely in place. This electrode, being in metallic connection with the containing chamber, is in electrical connection, through the bridge and cover, with the frame of the transmitter, which thus becomes one of the terminals.

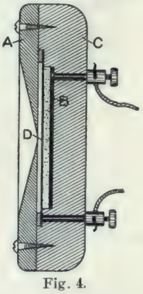

Fig. 4.

The front electrode is also backed by a brass disc, which is attached to the metal diaphragm of the transmitter by means of a stud that passes first through a mica washer which serves to enclose the electrode chamber, and then through the center of the diaphragm. This stud is fitted with two threads, upon one of which is screwed a nut which clamps the mica washer to the electrode; and upon the other, two nuts which clamp the electrode to the diaphragm. A brass collar, which screws to the periphery of the electrode chamber, binds the mica washer securely against it. Connection is made to the front electrode, which is the second terminal, by means of a fine wire brought out to a binding-post mounted upon an insulated block.

The vibrations of the diaphragm are communicated directly to the front electrode, which thus varies the pressure upon the mass of granular carbon and consequently serves to vary the resistance. Two damping springs rest against the diaphragm, thus keeping the amplitude of its vibrations within reasonable limits, and checking them as soon as they have performed their part, leaving the diaphragm ready to obey the impulses due to the succeeding sound waves.

This transmitter operates in a very satisfactory manner; excellent contact is made between the carbon electrodes and the particles of granular carbon. Packing of the granules is prevented on account of the space between the periphery of the electrodes and the inner circumference of the chamber, which contains granules that do not become heated by the passage of the current. Hence, when the granules between the electrodes become heated, they can expand into this portion.

The transmitters of this type manufactured by different companies vary slightly in minor details of construction, but all operate upon practically the same principles.

(To be concluded.)

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"Miller was a little, middle-aged man, with a closely clipped gray moustache. He had built up his business in the old-fashioned way, by personally attending to every detail himself. His was one of the stores where, as you used to read in the story books, the poor young country boy stood a good chance of being taken into partnership if he persisted in picking up all the pins from the floor and in carefully saving all the broken pieces of string until the head of the house happened to notice his habits of thrift and economy.

"It may be as well to remark, in passing, that there are none of that sort of stores left nowadays.

"Often in those days my old father used to wake me up at 5:30 o'clock in the morning and take me out on the back porch to watch Thomas Miller drive up to his store in the gray dawn.

"'There,' father would say, 'there's an example for a young man to follow. The richest merchant in town—yet he gets up every morning before dawn, takes care of his own delivery horse and wagon, and gets over here to the store before other people have left their beds. Now stay here and watch what happens.'

"Presently, after Miller had hitched his horse and made a light inside the store, I could see him sweeping the floor inside, and then he would come out, clad in blue overalls, and sweep the platform and the sidewalk.

"'He isn't afraid of work,' father would go on. 'He saves the wages of a hostler and also of a boy to sweep out the store and keep things well dusted. That's the reason he's so successful and so rich.'

"Well, Sir, I naturally got pretty full of that idea. I had almost come to believe that the way to make a success in life was to do everything yourself, when—thank my lucky stars!—another drygoods merchant came along and taught me how far wrong I was.

"This new chap came from the East. He was not thirty years old, and he was what we all called a 'tony dresser.' He rented a big store-room, less than half a block from the store of Thomas Miller & Company. People shook their heads and said that he should have started in a smaller way. Look how long it had taken Miller to build up his trade! The new man's name was John Harvey, and the first thing he did was to have a black and gold sign spread clear across the front of the building, reading 'Harvey's Home of Fashion.' The oldsters shook their heads again when they read that sign.

"But, worst of all, John Harvey upset all the rules by following which the great business of Thomas Miller & Company had been built up. He never

The following review of "Practical Lessons in Electricity" is taken from the Scientific American of January 30, 1904:

An examination of this work convinces us that the purpose for which it was issued, namely, to give the public an opportunity to judge of both the standard and scope of the instruction offered in the electrical engineering course of the American School of Correspondence at Armour Institute of Technology, is more than fulfilled. The book consists essentially of four parts, all distinguished by a common-sense treatment of a subject, which, particularly in its elementary conceptions, is apt to confuse the average student not a little. Prof. Crocker's wide experience as a teacher is apparent in the division on storage batteries. That portion of the work is characterized by a lucidity of treatment which is unfortunately not often found in books upon so recondite a subject. Mr. Cushing's division on electrical wiring may be regarded as an epitome of his well-known work on standard wiring —a simple, condensed account of what a fairly advanced student ought to know of this particular branch of applied electricity. Mr. Sager has performed what may well be considered the most difficult task allotted to any of the authors of this book, namely, that of presenting as tersely as possible the elementary conceptions of electricity. His first division on the rudiments of electricity follows more or less the beaten path of Silvanus Thompson and other writers of elementary text-books. In his division on the electric current, he has outlined with the help of fairly simple mathematics the work which the electric current is capable of performing. Not the least valuable part of the book to the student is a series of examination papers pertaining to the subjects treated.

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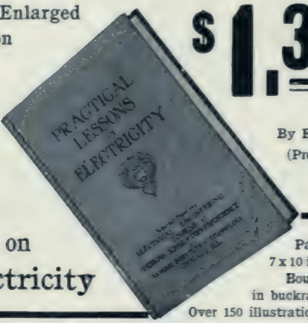

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thought of getting to his store until 8 o'clock, when its doors were opened to customers. He hired a boy to take care of his delivery horses and wagons, and another to sweep the store and keep things clear of dust. He spent most of his own time sitting at a big desk, looking out of the window and writing things.

"Father told me to watch him and see the result of that kind of extravagance. I did watch him. The first week after his store opened, a full-page advertisement appeared in all the local papers. It read:

> **Madame Bruneau, the New York Modiste, will be at Harvey's Home of Fashion all of this week, with a full line of Paris model gowns.**
>
> =
>
> Every lady in town is invited to call and inspect the new fall styles. Nothing will be sold the first day, and a **Souvenir** will be given to every caller.

"Well, Sir, the women just went down there in swarms—Mrs. Thomas Miller among them. Harvey, with his very smartest clothes on, stood at the front door and welcomed them. He was himself a regular walking advertisement for his home of fashion, and the women couldn't help but notice it. Instead of saving the odd pieces of string, he gave away a bunch of artificial violets to every woman who stuck her nose inside his place that first week.

"Every single week he got up some new scheme. And every week his trade plainly grew larger. Instead of spending his time currying the horses and sweeping out the store, he hired $6-a-week boys to do that work, and put in his own working hours devising schemes for capturing new customers.

"Pretty soon he had Thomas Miller & Company guessing. Within a year the old firm had lost more than half their trade. Old Miller finally braced up, and made a desperate effort to meet Harvey on his own ground. But he had had his mind on missing pins and on currycombs so long that he found it hard to concentrate his attention on anything else.

"Mrs. John Harvey had been from the first the best-dressed woman in town. Mrs. Thomas Miller, on the other hand, had always been a far from shining example of her husband's ideas of economy. Now the women of the town began to draw comparisons between them.

"'Miller's may be all right for the staple goods—on which, they tell me, there is a small profit; but if you want anything really smart and stylish—and there, by the way, lie large profits—why, plainly, Harvey's is the place to go to get it. Just look at the way Mrs. Harvey dresses!'

"That was the way the talk went round. And month after month Harvey won away more of Miller & Company's customers. Before I went to college the firm of Thomas Miller & Company had gone into bankruptcy, and its proprietor was working in Harvey's Home of Fashion as head of the silk counter.

"I suppose the lesson is plain. It was so to me, anyhow. The time has passed when any man can hope to look personally after all the details of any large business. If he wants to succeed, he must hire other people to do the comparatively unimportant work, and must devote himself to the task of getting new customers and extending his business in every possible way.

"The modern business man, who is working for a big success, must confine his attention to results. He needs chiefly the faculty of *picking out men.* For anything can be done, once you have found the right man to do it. All the great fortunes of the present day, in commercial and manufacturing lines at least, have been made by men who were wise enough and clever enough to hire other wise and clever men to work for them.

"In other words, the present is the age of organization."

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REACTIONS OF SUPPORTS

THIS subject is intimately related to that of "Strength of Materials," and a knowledge of its principles is essential to success in all kinds of structural engineering.

Moment of a Force

By "moment of a force" with respect to a point is meant its tendency to produce rotation about that point. Evidently the tendency depends on the magnitude of the force and on the perpendicular distance of the line of action of the force from the point—the greater the force and the perpendicular distance, the greater the tendency; hence the moment of a force with respect to a point equals the product of the force and the perpendicular distance from the force to the point.

The point with respect to which the moment of one or more forces is taken is called an "origin" or "center" of moments; and the perpendicular distance from an origin of moments to the line of action of a force is called the arm of the force with respect to that origin. Thus, if F_1 and F_2 (Fig. 1) are forces, their arms with respect to O' are a_1' and a_2' respectively, and their moments are $F_1a'_1$ and $F_2a'_2$. With respect to O'' their arms are a_1'' and a_2'' respectively, and their moments are $F_1a''_1$ and $F_2a''_2$.

If the force is expressed in pounds and its arm in feet, the moment is in foot-pounds; if the force is in pounds and the arm in inches, the moment is in inch-pounds.

A sign is given to the moment of a force for convenience, the rule used herein being as follows: The moment of a force about a point is positive or negative, according as it tends to turn the body about that point in the clockwise or counter-clockwise direction.*

Thus in Fig. 1:

The moment of F_1 about O' is negative, about O'' positive.

The moment of F_2 about O' is negative, about O'' negative.

Principle of Moments

In general, a single force of proper magnitude and line of action can balance any number of forces. That single force is called the equilibrant of the forces, and the single force that would balance the equilibrant is called the resultant of the forces. Or, in other words, the resultant of any number of forces is a force which produces the same effect. It can be proved that the algebraic sum of the moments of any number of forces with respect to a point equals the moment of their resultant about that point.

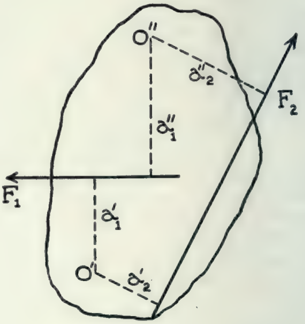

Fig. 1.

All the forces acting upon a body which is at rest are said to be balanced or in equilibrium. No force is required to balance such forces, and hence their equilibrant and resultant are zero.

Since their resultant is zero, the algebraic sum of the moments of any number of forces which are balanced or in equilibrium equals zero.

This is known as the principle of moments for forces in equilibrium; for

---

*By clockwise direction is meant that in which the hands of a clock rotate; and by counter-clockwise, the opposite direction.

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brevity it may be called "the principle of moments."

The principle is easily verified in a simple case. Thus, let A B, Fig. 2, be a beam resting on supports at C and F. It is evident from the symmetry of the loading that each reaction equals one-half of the whole load, that is, $\frac{1}{2}$ of 6,000 = 3,000 pounds. (We may neglect the weight of the beam for simplicity.)

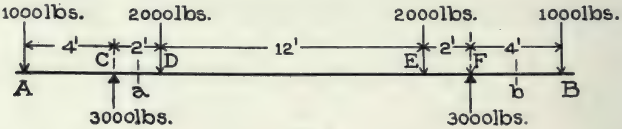

Fig. 2.

With respect to C, for example, the moments of the forces are, taking them in order from the left:

— 1,000 x 4 = — 4,000 foot-pounds.
3,000 x 0 = 0 "
2,000 x 2 = 4,000 "
2,000 x 14 = 28,000 "
— 3,000 x 16 = — 48,000 "
1,000 x 20 = 20,000 "

The algebraic sum of these moments is seen to equal zero.

Again, with respect to B, the moments are:

— 1,000 x 24 = — 24,000 foot-pounds.
3,000 x 20 = 60,000 "
— 2,000 x 18 = — 36,000 "
— 2,000 x 6 = — 12,000 "
3,000 x 4 = 12,000 "
1,000 x 0 = 0 "

The sum of these moments also equals zero. In fact, no matter where the center of moments is taken it will be found in this and any other balanced system of forces that the algebraic sum of their moments equals zero. The chief use that we shall make of this principle is in finding the supporting forces of loaded beams.

Kinds of Beams

A *cantilever* beam is one resting on one support or fixed at one end, as in a wall, the other end being free.

A *simple* beam is one resting on two supports.

A *restrained* beam is one fixed at both ends; a beam fixed at one end and resting on a support at the other is said to be restrained at the fixed end and simply supported at the other.

A *continuous* beam is one resting on more than two supports.

Determination of Reactions

The forces which the supports exert on a beam, that is, the "supporting forces," are called "reactions." Let us deal chiefly with the simple beams. The reaction on a cantilever beam supported at one point evidently equals the total load on the beam.

When the loads on a horizontal beam are all vertical (and this is usually the case), the supporting forces are also vertical, and the sum of the reactions equals the sum of the loads. This principle is sometimes useful in determining reactions, but in the case of simple beams the principle of moments is sufficient. The general method of determining reactions is as follows:

1. Write out two equations of moments for all the forces (loads and reactions) acting on the beam with origins of moments at the supports.

2. Solve the equations for the reactions.

3. As a check, ascertain whether or not the sum of the reactions equals the sum of the loads.

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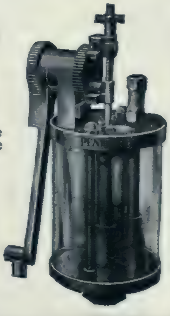

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Let us fix these principles in mind by a few examples:

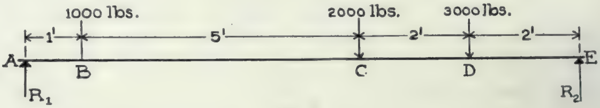

Fig. 3.

1. Fig. 3 represents a beam supported at its ends and sustaining three loads. To find the reactions due to these loads, let the reactions be denoted by R_1 and R_2, as shown; then the moment equations are:

For origin at A:

$1{,}000 \times 1 + 2{,}000 \times 6 + 3{,}000 \times 8 - R_2 \times 10 = 0.$

For origin at E:

$R_1 \times 10 - 1{,}000 \times 9 - 2{,}000 \times 4 - 3{,}000 \times 2 = 0.$

The first equation reduces to:

$10\ R_2 = 1{,}000 + 12{,}000 + 24{,}000 = 37{,}000$; or $R_2 = 3{,}700$ pounds.

The second equation reduces to:

$10\ R_1 = 9{,}000 + 8{,}000 + 6{,}000 = 23{,}000$; or $R_1 = 2{,}300$ pounds.

The sum of the loads is 6,000 pounds, and the sum of the reactions is the same; hence the computation is correct.

2. Fig. 4 represents a beam supported at B and D (that is, it has overhanging ends), and sustaining three loads, as shown. We wish to determine the reactions due to the loads.

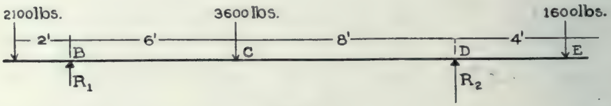

Fig. 4.

Let R_1 and R_2 denote the reactions as shown; then the moment equations are:

For origin at B:

$-2{,}100 \times 2 + 0 + 3{,}600 \times 6 - R_2 \times 14 + 1{,}600 \times 18 = 0.$

For origin at D:

$-2{,}100 \times 16 + R_1 \times 14 - 3{,}600 \times 8 + 0 + 1{,}600 \times 4 = 0.$

The first equation reduces to:

$14\ R_2 = -4{,}200 + 21{,}600 + 28{,}800 = 46{,}200$; or $R_2 = 3{,}300$ pounds.

The second equation reduces to:

$14\ R_1 = 33{,}600 + 28{,}800 - 6{,}400 = 56{,}000$; or $R_1 = 4{,}000$ pounds.

The sum of the loads equals 73,00 pounds, and the sum of the reactions is the same; hence the computation checks.

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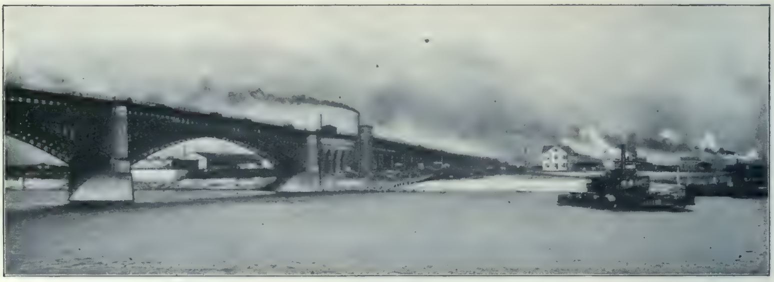
JAMES B. EADS

THE REMARKABLE LIFE STORY OF A GREAT AMERICAN ENGINEER

ABOUT the year 1833 if you had passed along the main thoroughfare of the city of St. Louis, Missouri, you would have noticed a bright-eyed little boy standing on a corner selling apples. Day after day a stream of people passed the lad, though none of them dreamed that this urchin, selling apples at three for five cents, would in time cut his name deeper in the history of St. Louis than any other man of his generation.

A merchant, who had noticed the business enterprise of the lad, took him into his warehouse, and for five years the boy worked as a clerk. Indoor life, however, was irksome to young Eads, and he secured the position of purser aboard a Mississippi river steamer. In this occupation the young man found himself in his natural element. He was not merely pleased with the life on shipboard; he delighted in the river itself—its bars, the manner in which it piled up the sediment on one side of the bank and cut into the farms on the other, its way of making new channels, and the great loss to shipping interests that was caused by the eccentricities of the great "Father of Waters."

The study of the river led Eads to give up his pursership and engage in the business of raising sunken boats. His first contract was to bring to the surface a barge-load of pig iron. When his workmen arrived at the spot where the barge had sunk—212 miles from St. Louis—the current was so swift that the diver refused to go down, and returned to St. Louis. Eads, without any hesitation, manufactured a diving-bell out of two barrels, went down himself, and completed the work. This is a typical illustration of the man. He permitted nothing to stand in his way. If a workman refused to perform his task, Eads was ready to step into the breach and take hold of it himself. The result of such methods was to inspire his workmen with the feeling that he could overcome any difficulty, and, in consequence, Eads got better service than any of his competitors.



EASTERN EXTREMITY AND APPROACHES OF THE EADS BRIDGE ACROSS THE MISSISSIPPI RIVER AT ST. LOUIS, MO.

With the exception of two years, during which he married and lived in Pittsburg, Eads continued the work of the wrecking business and the building of boats. He built six turreted iron gunboats, seven transports, and four mortar boats for the Government during

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But the crowning achievement of the man who, as a boy, sold apples on the city streets—the work that will carry his name down through posterity—is the magnificent Eads bridge at St. Louis spanning the Mississippi river between Missouri and Illinois—a bridge with arches almost unheard-of in those days, of 500-foot span and 60 feet clear above the river. As in all his other work, Eads emphasized strength. He built two river piers of heavy masonry, going down 110 feet below the surface to get a rock foundation. For the building of these piers, Eads designed and worked out a plan for air-tight caissons, sand propellers, conveyors, and the like. The steel arches of this bridge—two of over 500 feet—were the largest ever constructed up to 1876. To-day the bridge stands a monument to Eads's engineering genius.

Space would not permit detailed reference here to the great work Eads accomplished for the shipping interests of the Mississippi. His jetties and methods of maintaining channels have been wonderfully successful, and have raised New Orleans to the position of one of the most important export cities of the nation.

When De Lesseps urged the building of the Panama canal, Eads proposed a scheme for a ship railway across the Isthmus—a railroad on which would run immense cradles, capable of carrying the largest ships. The plan was endorsed by many engineers, but the death of Eads in 1887 put a stop to the undertaking.

In our day a good many people preach that the opportunities to rise from humble to prominent positions in the industrial world have passed, when the truth is that never was there a period so prolific in opportunities as the age in which we live. But these opportunities are for boys like Eads who have energy and ambition and are not afraid of work. Do not "fool" yourself; opportunities for promotion are all around, but remember that you must be awake and capable of handling them.

SHEET METAL ELBOWS

A TOPIC OF SPECIAL INTEREST TO ALL SHEET METAL WORKERS

PROBABLY the elbow is the most important article in the sheet-metal worker's line. Before taking up the method of obtaining the patterns, the rule will be given for calculating the rise of the miter line for any size or number of pieces.

Determination of Miter Lines

No matter how many pieces an elbow has, they join together and form an angle of 90°. Thus, a two-pieced, three-pieced, four-, five-, or six-pieced elbow is a right-angled elbow made up of that number of pieces. In Fig. 1 is shown a two-pieced elbow placed in the quadrant C B, which equals 90° and makes C A B a right angle. From A draw the miter line A *a* at an angle of 45° to the base-line A B. Then parallel to A B and A C and

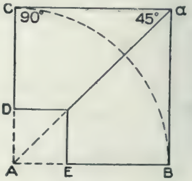
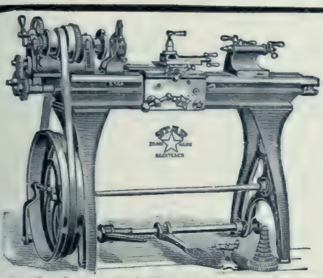


Fig. 1.



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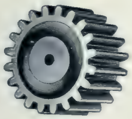

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tangent to the quadrant at C and B, draw lines to intersect the miter line, as shown. Knowing the diameter of the pipe, as C D or E B, draw lines parallel to the arms of the pipe, as shown. Then C B E D will be a two-pieced elbow, whose miter line is an angle of 45°.

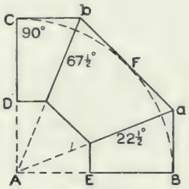

Fig. 2.

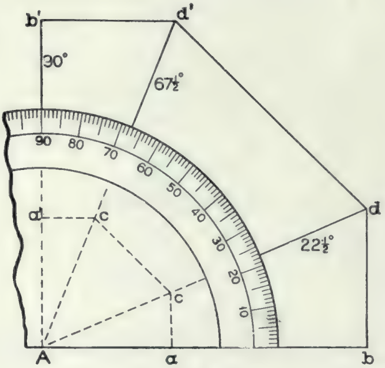

Fig. 5.

In a similar manner draw the quadrant B C, Fig. 2, in which it is desired to draw a three-pieced elbow. Now follow this simple rule, which is applicable for any number of pieces: Let the top piece of the elbow represent 1, also the lower piece 1, and for every piece between the top and bottom add 2. Thus in a three pieced elbow:

Top piece equals - - - -	1
Bottom piece equals - - -	1
One piece between equals - -	2
Total equals - - - - - -	4

Now, dividing the quadrant of 90° by 4, we have: 90 ÷ 4 = 22½. As one piece equals 22½°, draw the lower miter line A *a* at that angle to the base-line A B. Then, as the middle piece represents two by the above rule, add 45 to 22½ and draw the second miter line A *b*, at an angle of 67½° to the base-line A B. Now, tangent to the quadrant at C and B, draw the vertical and horizontal lines shown, until they intersect the miter lines, from which intersections draw the middle line, which will be tangent to the quadrant at F. C D and B E show the diameters of the pipe, which are drawn parallel to the lines of the elbow shown.

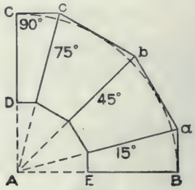

Fig. 3.

Fig. 3 shows a four-pieced elbow, to which the same rule is applied. Thus the top and bottom piece together equal 2, and the two middle pieces equal 4; total, 6. Dividing the quadrant of 90° by 6 gives: 90 ÷ 6 = 15. Then the first miter line A *a* will equal 15°, the second A *b* 45°, the third A *c* 75°, and the vertical line A C 90°.

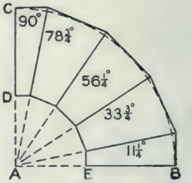

Fig. 4.

Another example is given in Fig. 4, which shows a five-pieced elbow, in which the top and bottom pieces equal 2, and the three middle pieces 6; total, 8. Dividing 90 by 8, we have: 90 ÷ 8 = 11¼. The first miter line, therefore, will equal 11¼°, the second 33¾°, the third 56¼°, and the fourth 78¾°. By using this method, an elbow having any number of pieces may be laid out. When drawing these miter lines, it is well to use the protractor shown in Fig. 5, which illustrates the manner of laying out a three-pieced elbow. From the center point A of the protractor, draw lines through 22½° and 67½°. Now set off A *a*, and

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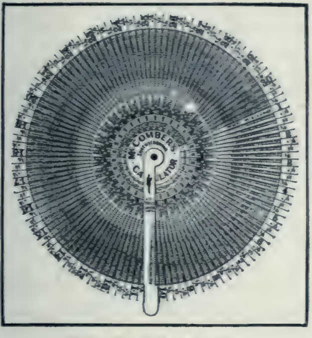

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the diameter of the pipe *a b*. Draw vertical lines from *a* and *b* to the miter line at *c* and *d*. Lay off similar distances from A to *a'* to *b'*, and draw horizontal lines intersecting the 67½° miter line at *c'* and *d'*. Then draw the lines *d d'* and *c c'* to complete the elbow. In practice, however, it is not necessary to draw out the entire view of the elbow; all that is required is the first miter line.

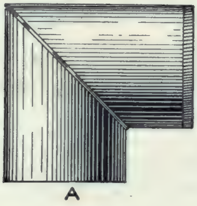

Fig. 6.

Drawing of the Pattern

To obtain the pattern for any elbow, using but the first miter line, proceed as follows:

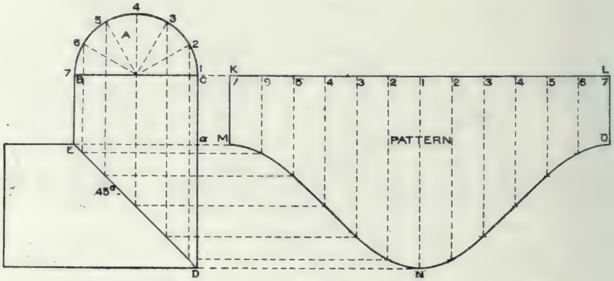

Fig. 7.

Let Fig. 6 represent a two-pieced elbow for which patterns are desired. First draw a half section of the elbow as shown at A in Fig. 7, which is a circle. Divide the lower half into equal spaces, and number the points of division 1 to 7. Now follow the rule previously given: The top and bottom piece equals 2; then, for a two-pieced elbow, divide 90 by 2. In its proper position below the section A, draw B C D E, making E D 45°. From the various points of intersection in A, drop vertical lines intersecting E D as shown. In line with B C, draw K L, upon which place twice the number of spaces contained in the section A, as shown by similar figures on K L; from these points drop perpendiculars to intersect with lines drawn from similar intersections on E D, parallel to K L. Trace a line through the points shown; then K L O N M will be the pattern. To this, laps must be allowed for seaming.

Now, to obtain the pattern for the three-pieced elbow shown in Fig. 8: Top and bottom pieces equal 2, one middle piece equals 2; total, 4; and 90 ÷ 4 = 22½. Then, in line with F G (Fig. 9), draw F G J H, making H J at an angle of 22½° to the line H *b*. Proceed as for Fig. 7, using the same stretchout line; then U P R S T will be the desired pattern. It should be understood that when the protractor is used for obtaining the angle as shown in Fig. 5, the heights *a c* and *b d*, measured from the horizontal line, form the basis for obtaining the heights of the middle pieces, inasmuch as they represent one-half the distance;

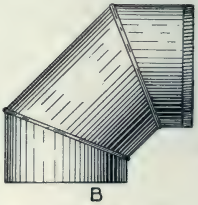

Fig. 8.

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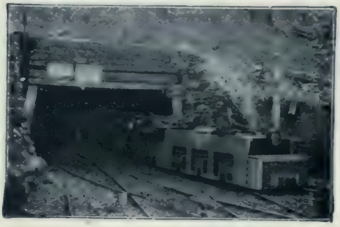

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for this reason the middle pieces count 2 when using the rule. Therefore, the distances F H and G J (Fig. 9) represent one-half of the center piece, and U T S R P one-half of the pattern for the center piece, of a three-pieced elbow. As in Fig. 7, allowance must be made for seaming.

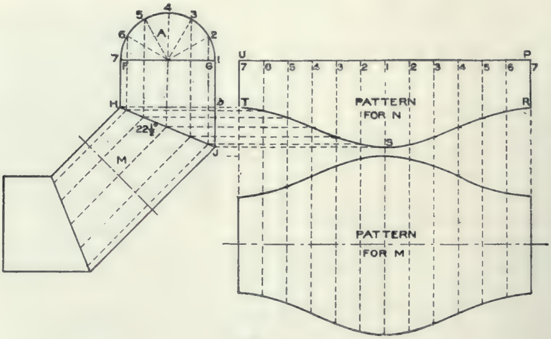

Fig. 9.

PRACTICAL TALKS BY PRACTICAL MEN

II.—ADDRESS DELIVERED BEFORE THE STUDENTS OF ARMOUR INSTITUTE OF TECHNOLOGY, OCTOBER 26, 1903

By CHARLES F. HART

Vice-President, National Association of Stationary Engineers
Chicago, Ill.

GENTLEMEN: "Perhaps the thing which has caused me the keenest regret is the fact that I never had an opportunity to get a thorough technical education. Twenty years ago, when I was in a position to take advantage of such an opportunity, none was open to me, except at a tremendous expense, which I could not afford, or thought that I could not. But perhaps I am a little closer to this matter of technical education than any one might think. For a number of years, the Association of which I am a member has conducted examinations for stationary engineers in the city of Chicago, and there has been considerable feeling among many of the applicants because Armour Institute graduates have walked off with all the highest honors.

"We had an examination some three years ago for a stationary engineer of the fifth grade for a pumping station. The two leaders in that examination were comparative boys, and graduates of Armour Institute of less than one year. That shows you what it is possible to do. There were taking that examination twenty engineers of more than ordinary ability, and ten who to my mind were very fine operating engineers; but they had never reasoned on the basis of cause and effect. There was an effect produced—they knew that—but they did not know the cause of it. They also had never had the training in English which would enable them to express themselves intelligently and well. There was much dissatisfaction because the highest grades were given to the youngest and most

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inexperienced applicants, and the result was that a meeting of the Examining Committee was called. After going carefully over all the papers and comparing them, it was conceded that the two highest on the list well deserved that honor notwithstanding their youth.

* * * * * *

"Our organization, the National Association of Stationary Engineers, was started twenty-one years ago yesterday, October 25, 1882, with no other end in view than to educate engineers, not simply from a technical or a professional standpoint, but to bring their knowledge up to the rank of professional men. We have not quite succeeded in doing this; but if our time and patience hold out, we are going to do it. Twenty-one years ago, when our order was instituted, we were just starting in the field of technical education. The Corliss engine, dynamo-electric machinery, high steam pressure, electric transmission, and all the higher branches of steam and electrical engineering were practically unknown.

CHARLES F. HART.

* * * * * *

"Now, Armour Institute gives us just such practical opportunities as are needed to make the stationary engineer a professional man. Disabuse your mind of the idea that the stationary engineer is rather the 'under dog,' so to speak. I say to you, look out for the stationary engineer. There is more under his hat than you have any idea of. He has been through a line of work that called for close judgment. There is a saying that it is not what you know, but what you make the other fellow think you know, that counts. If a man goes out, faces the world, and makes money by what he knows, that is nothing; but a man who does not know a 'blooming' thing, but goes out and makes the world think he does, he is the man for me. That has practically been the case with the stationary engineer during the past twenty-five years. He has been called up into the office and told, 'John, we want to ventilate this building.' 'All right, Sir.' He doesn't know a thing about ventilation, but he isn't going to tell the boss so. He goes down and talks the matter over with the men; and, among the bunch, they manage to fix up a plan of ventilation, which he hands in to the boss, and it is all right.

* * * * * *

"My early conception or idea of a college was a beautiful place out on a picturesque hill, with a stream of water flowing by. These things are all fine and beautiful and have their value, but they do not bring in the money. It is the coal, iron, steel—the vulgar things of the world, so to speak—that have the greatest practical value. Your situation here in the midst of a manufacturing district is an ideal one for you. As you go to and from your class-room, you can step into a plant and see the practical applications of what you are studying. This is of vast importance to you, and could not be had if the college were situated out in the beautiful country."

In closing, Mr. Hart gave a most hearty invitation to the students to visit the Record-Herald Building, of which he is Chief Engineer, and inspect the new machinery which is in successful operation there. He also extended a cordial invitation to them to attend the meetings of his organization, which are held on the first and third Wednesdays of each month at No. 70 East Adams Street, beginning at 8:30 P. M.

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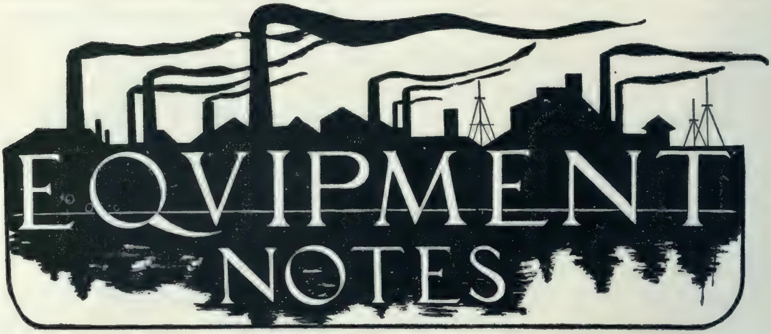

EQVIPMENT NOTES

ONE of the largest and handsomest highway draw spans ever built, is the McComb's Dam bridge across the Harlem river, New York City. Its length is nearly 400 feet; it has a 40-foot roadway and, in addition, two sidewalks, each nearly 10 feet wide. The weight of the moving mass is about 2,200 tons, and until recently it had been operated by a 40-H.-P. oscillating cylinder steam engine with differential gear, reducing its speed from 19 to 1. The ends of the bridge were lifted by a separate mechanism with hydraulic jacks operated from an accumulator in the engine room. It was locked by hydraulic centering rams. About two minutes was required for opening or closing the draw, and the mechanism was maintained at great expense. To simplify and expedite matters, the engine has been replaced by a 20-H.-P. alternating-current motor furnished by the General Electric Company, and said to be the first one of its size and kind to be used for such a purpose. The motor is connected by a clutch to a system of gears and shafts, which extend from the center of the bridge to both ends and operate toggle joints that take the place of the hydraulic lifting apparatus. An automatic device designed by Boller & Hodge, New York, takes the place of the latch formerly used. The services of only one man will now be required where three were formerly employed, and it is thought that the bridge can be opened or closed in one minute or less. The employees of the Department of Bridges, New York, have had charge of the improvements, and the machine work was done in the Brooklyn Bridge shops.

Orders have been received for Parsons steam turbines for installation in the extension of the Ultimo central power station of the City of Sydney and the suburban electric traction system, which is operated by the New South Wales Government. The present equipment of the power house was contracted for with the General Electric Company, and the engines are of the Allis build. The capacity of the additional installation will be about 5,000 horse-power.

It has been announced that a third-rail electric railway is soon to be built between Elmira and Corning, New York. A private right of way has already been secured, and application will at once be made to the State Railroad Commissioners for the necessary permission.

The municipal authorities of the City of Mexico have approved the plans of the Mexican Traction Company for the electrical conversion of the Circuito de Barrios tramways, a mule line running through the heart of the Mexican capital. The system—which will cover more than 100 miles—will be built by Pittsburg capitalists. The power plant will have an initial capacity of 2,000 horse-power. Twenty 40-foot cars with four motor equipments of 56 horse-power each will be ordered at first. The entire system is expected to be in operation in less than a year.

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The General Council of the city of NEWPORT, KY., has recently appropriated $10,000 toward the construction of a municipal electric light plant. A similar sum is to be set aside annually until the entire cost of construction is covered.

A project has been set on foot for the development of the power of the Walla Walla river, by the Northwestern Gas & Electric Company of Los Angeles, California. The probable cost of the work will be $250,000.

THE BOSTON AND LOCKPORT BLOCK COMPANY, 160 Commercial street, Boston, Mass., made the blocks for the *Minnesota* and the *Dakota*, recently built by the Eastern Shipbuilding Company, New London, Conn. These blocks are made from a special design, and incorporate all the latest improvements. The cargo blocks are of steel, and the boat blocks have wooden shells. The total weight of the outfit for each ship is about twenty tons, and the value is about four times as much as the cost of blocks required for an ordinary four-masted ship. The capacity of the largest blocks is from forty to sixty tons each.

WM. T. BONNER & COMPANY, 53 State street, Boston, Mass., report that Klinger reflex gauges and Wiltbonco gauge mountings are becoming very extensively used not only in the United States and foreign navies, merchant ships, ferryboats, and private yachts, but also in many stationary power plants. These gauges were fitted to all the boilers on the United States torpedo destroyers which recently sailed from Norfolk, Va., to the Philippines.

* * *

CORRESPONDENCE WORK IN THE EAST

DURING the month of March, Dr. William A. Colledge, Dean of the American School of Correspondence, spent two weeks in the East. In Lynn, Lawrence, and Worcester, Massachusetts, he delivered an interesting lecture entitled "Our Wonderful Century and its Industrial Opportunities." While in Lynn, Dr. Colledge received from the Boston Machine Company the blue prints of an exceedingly intricate piece of machinery designed and drawn by Benjamin A. Slocum, an American School student. This drawing will be seen in our exhibit at the St. Louis Exposition.

In Boston Dr. Colledge met the students at Young's Hotel, and two very pleasant evenings were spent. One of the main topics of discussion was the forming of a club to bring all the Boston students together once or twice a month. There is every prospect that in the near future this plan will materialize.

In each city visited the students were enthusiastic over their studies. Occasionally one would acknowledge that he had fallen behind in his work, but he invariably promised to take a new grip and begin again.

Through these trips of the Dean, the American School is showing not only renewed but enlarged interest in the welfare of its students—a desire to come into close touch with all the men who are taking courses. Dr. Colledge's mission is not merely to lecture at various centers and arouse a new interest in technical education; for such a work, he could not be spared from the School. The chief motive for these visits is to make the School of genuine assistance and value to the students—to advise and help any student, be the difficulty or problem that of work or of study.

When you receive a notice that the Dean will be in your city, do not fail to meet him. Any of our students who would like to have Dr. Colledge visit their city and deliver a lecture, may write to the School to that effect; and, if possible, the matter will be arranged. A full account of Dr. Colledge's eastern trip will appear in our next issue.

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In order to quickly increase our circulation, and as a special inducement to students of the American School of Correspondence, we offer a year's subscription to **FIREPROOF,** and a copy of the book **Modern Fireproofing,** for the regular price of subscription to the magazine, **$1.00,** and in addition will send **FREE** a copy of the March issue of **FIREPROOF,** devoted exclusively to the Great Baltimore Fire, with articles by America's leading architects and engineers. More than 50 illustrations.

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GRADUATE AND STUDENT NOTES

THE ANNUAL RECEPTION

A RECEPTION similar to the one given last year by Armour Institute of Technology to the students of the American School of Correspondence, will be held about the middle of June. Dr. Gunsaulus is making arrangements to have some prominent public man address the students.

We make this preliminary announcement so that our students may keep the event in mind. The May issue of THE TECHNICAL WORLD will contain further information about the reception.

Several students of the American School of Correspondence are officers in the Japanese Navy. We have not heard from them since the outbreak of the war, but there is little doubt that they have been engaged in the naval battles. We expect in the near future to receive some communications which will be of great interest to their fellow-students, as well as to all our readers.

Letters of inquiry as to the courses offered by the American School of Correspondence, have recently been received from young men aboard the Russian cruiser *Diana* at Port Arthur and the United States gunboat *Vicksburg* at Chemulpo, Korea. These go to show the far-reaching influence of the work that is being done by the School.

Readers of THE TECHNICAL WORLD will find a very wide field of mechanical and scientific interest represented by the numerous manufacturers and business firms included in our list of advertisers. Those contemplating new installations, in search of latest improved devices, etc., cannot do better than keep an eye on announcements appearing in our advertising pages. The catalogues issued by many of these manufacturers have, in addition to their immediate utility and artistic beauty, a permanent value as works of genuine scientific interest.

H. S. Cover, of South Bend, Indiana, is now at the head of a manufacturing institution which he established soon after graduating. The products of his firm consist of dressed mill cogs and patent automatic rubber respirators for use in smoke, fumes, vapors, and all kinds of dust. Mr. Cover designed and built the special machinery himself, and he writes that his course by correspondence was of great value in inventing, designing, and installing the machinery of the shop. His plant is operated by a three-phase induction motor direct-connected to the heaviest machine.

H. S. COVER.

SUBSCRIBERS are urged to examine and make use of the "Compendium of Drawing" and the "Practical Lessons in Electricity" just published by the American School of Correspondence. These can be seen in your local public library; or, if not yet on the shelves, a request for the books addressed to the librarian will secure them.

Louis Geizer, Dufferin Gold Mines, Nova Scotia, is putting his studies into practical operation. He has been engaged in gold mining for the last five years, four of which he spent with the Montreal, London Company, Limited, and last summer he was placed in entire charge of their plant.

W. A. Noble, one of our students in Korea, in a letter received during the month of February, writes:

> "It may be of interest to the School to know that Korea is greatly agitated over the threatened war between Japan and Russia. We are expecting Japanese troops daily. The American Legation guard will land in a day or two. Missionaries have been warned that it is unsafe to travel in the interior for the present. I have to return on foot to Pyeng-yang. We fear little trouble unless it be from mobs attacking the defenseless communities of the interior."

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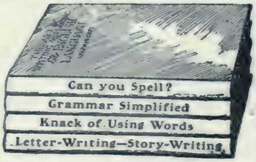

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M. A. LEHMAN.

M. A. Lehman, of Princeville, Oregon, has found his work with the School of the greatest practical value. When he took up his studies he was a fireman in a saw-mill. Since then Mr. Lehman has served successively as engineer, sawyer, and manager. In a letter written us some time ago, he says:

"I have found my studies extremely valuable. They enable me to grasp the principles of the problems which underlie my trade. I have more confidence in myself, and, as a result, do better work."

E. C. Chodjko, one of our students in Hai-phung, China, describes in a letter the manner in which he prepares his work for examination:

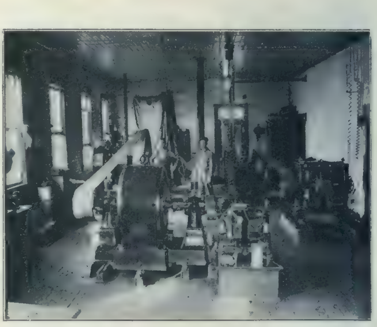
"I first do every one of the practice problems, and never pass to the next one without having completely mastered the one before. Then I work all the examination problems in a scratch-book. When all are thoroughly finished, they are copied on the examination sheets. I then re-do them all as if not done at all, to check and correct them. Only then are they sent to the School. I take all the possible care to prepare my work in the best way I can, as I mean to succeed, and I hope to."

The following is a description of the interior of the Nashville Electric Light Company's plant, designed and installed by one of our students, John G. Peebles, of Nashville, Illinois:

The entire equipment consists of two 100-H.-P. horizontal-tubular boilers, two duplex steam pumps, heater, one 12 x 12-inch Ideal automatic high-speed engine belted to a 70-K. W. 1,100-volt 125-cycle alternator, one 8 x 10-inch Ideal automatic high-speed engine belted to a 45-light "Wood" D. C. series arc dynamo, and a combined switchboard for the two systems, as shown in the picture.

By reference to the illustration, it will readily be seen that all parts of the plant are so arranged as to give ample room for the attendant to pass around and through the different parts of the station when looking after the different machines; and in case of heavy repairs or renewal of parts being necessary, there is ample room to work without getting too near any machine that may be in operation.

Having the two systems (arc-light and incandescent) entirely separate and distinct from each other, enables the lighting company to operate each system with the proper sized engine without having to run an engine large enough to work both systems while only one system is being operated, as is the case where the "moonlight" schedule is used. Again, when only one engine is used to run all dynamos and it becomes crippled or disabled, the whole plant is shut down; but with the arrangement here shown, an entire shut-down need never occur.



NASHVILLE ELECTRIC LIGHT COMPANY'S POWER HOUSE.
Reconstructed and enlarged by J. G. Peebles.
The dynamo tenders, appearing in the picture, are Ed. Stoker and A. Winfree, the latter bareheaded.

JOHN G. PEEBLES

The plant is so designed that either boiler can be put into or out of service, or both may be operated together, without interfering with the service; either of the pumps can be made to feed the boilers, and the other one put into cold-water service by closing and opening the proper valves; and either of the lighting systems can be put into or out of service

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GRADUATE AND STUDENT NOTES—(Continued)

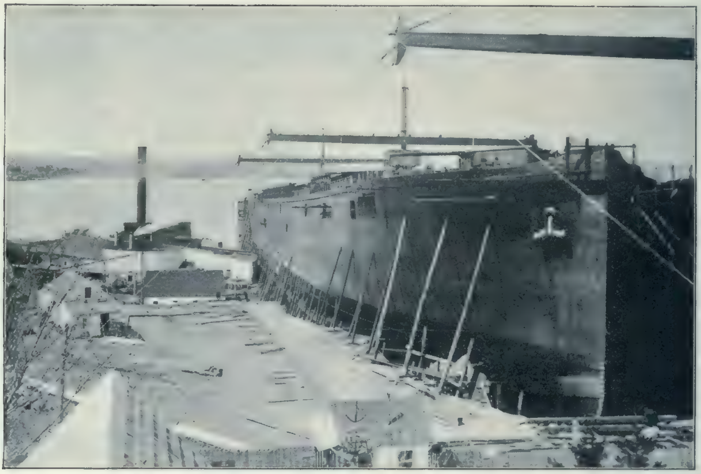
without in any way interfering with the other.

"With the arrangement shown and thus briefly described," says Mr. Peebles, "I have found by experience that this is the most economical plan to follow, costing less to operate and having fewer break-downs than any other arrangement I have ever tried or seen. Local conditions would have to determine the necessary changes to be made in this arrangement according to the requirements of the town."

H. W. Washburn, of New London, Conn., is employed with the Eastern Shipbuilding Company, who at the present time are just completing the building of two large ships—the *Minnesota* and the *Dakota*—for James J. Hill, president of the Great Northern Railway, to be used in the Pacific trade. In a description of these vessels, Mr. Washburn says:

> "The ships are 630 feet long and 73½ feet broad. Two propellers to each ship; the sweep of the blades is 23 feet; the hub to which the three blades are bolted is 5 feet in diameter, each blade being 9 feet long. The gross tonnage is 21,000 tons."

Mr. Washburn is studying the heating and ventilating systems to be used in these ships, and will describe them in an article which he is preparing for THE TECHNICAL WORLD.



THE MERCHANT LINER *MINNESOTA*, SISTER SHIP TO THE *DAKOTA*.
Now building at the yards of the Eastern Shipbuilding Company, New London, Conn.

George Switzer, of Watertown, N. Y., has been engaged as instructor in the Electrical Department of the Y. M. C. A. night school in that city.

Charles C. Eicliff, of Detroit, Michigan, one of our graduates, has successfully passed two United States Government Inspectors' examinations, and has had the satisfaction of standing near the head of the list. He is chief engineer on one of the best-known lake steamers.

H. J. Zellefrew, of New Kensington, Pa., one of our graduates in the Mechanical Engineering course, has for the past few months been superintending the building of a hotel at MacDonald, Pa.

O. J. Peterson, Worcester, Mass., a graduate of our School, has been in the employ of George S. Harwood & Son for seventeen years. He now holds the position of foreman of the woodworking department and drafting room.

EMPLOYMENT DEPARTMENT

TO EMPLOYERS:—The editors of The Technical World will be glad to bring employers of skilled labor into communication with trained and efficient men. Write the Employment Department full particulars as to the qualifications necessary.

POSITION VACANT

WANTED—Superintendent for Municipal Electric Light and Water Commission plant in Michigan. Position requires ability to take charge of books and collections, install meters and arc lamps and outside and inside wiring. Best of references required. Address *The Technical World,* No. 131.

POSITIONS WANTED

WANTED—Position as mechanical draftsman by young man 24 years of age. Has had experience in machine shop work, telephone construction work, and office work. Address *The Technical World,* No. 112.

A young man with three and one-half years' experience desires position as draftsman, preferably in Chicago. Can show specimens of work if desired. Lowest salary accepted, $14. Address *The Technical World,* No. 114.

A young man having had some experience in electrical work desires position as apprentice in that line. Would prefer work in vicinity of Schenectady. Address *The Technical World,* No. 24.

A young man of two years' experience desires position as chemist assistant. Locality desired, Chicago. Lowest salary accepted, $10 per week. Age, 28 years. Address *The Technical World,* No. 106.

A young man of three years' experience desires a position as engineer helper in electrical plant; not particular as to locality. Address *The Technical World,* No. 111.

A young man, 31 years of age, with fourteen years of experience, desires position as foreman of machine shop, preferably in Chicago or immediate vicinity. Lowest salary accepted is $100. Address *The Technical World,* No. 101.

A young man with varied experience in engineering work is desirous of obtaining a position as draftsman in Chicago or southern suburbs. Least salary accepted, $20 a week. Address *The Technical World,* No. 110.

WANTED—Position by experienced workman of 40, as general superintendent of shop. Can furnish excellent references. Lowest salary accepted, $100 per month. Address *The Technical World,* No. 113.

A young experienced electrician desires position as electrician with some good company in Chicago. He is a single man, 28 years of age, American, and weighs 133 pounds. Address *The Technical World,* No. 102.

WANTED—Position as shop foreman or head draftsman by young man, 26 years of age, weighing 120 pounds, having had three years' experience with special machinery. Would accept no lower salary than $100 a month. Address *The Technical World,* No. 100.

SITUATION WANTED—By an electrician. Understands general electric construction and repairing. Prefers Telephone Company or Electrical Engineering firm in the states of Massachusetts or Rhode Island. Best references. Least salary accepted, $60 per month. Graduate of American School of Correspondence. Address *The Technical World,* No. 121.

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BOOKS

American Telephone Practice. By Kempster B. Miller, M. E. Third edition, revised and enlarged. Pages 518. New York: McGraw Publising Co. Price, $3.00.

This excellent work on the telephone treats the subject from a thoroughly practical standpoint with the use of almost no mathematics. It takes up the general principles of telephony, the design and construction of commercial apparatus, the circuits connecting such apparatus into operative systems, and the methods used in the construction, operation, and maintenance of the systems. Both the Bell apparatus and methods, and those of the independent companies are taken up impartially.

The book is profusely illustrated, containing some 380 cuts and diagrams, all of which are clearly explained in the text. The important subjects of overhead and underground construction are taken up, as well as the laying of conduits and the drawing in of cables. Another chapter is devoted to a clear description of the apparatus and methods used in making the electrical tests required in commercial telephone work. In addition to the contents of the earlier editions, this latest edition contains several new chapters—one, for instance, on the storage battery, while another new chapter gives complete working specifications for exchanges according to the latest practice in both inside and outside construction. Still another chapter added treats of automatic telephone exchanges.

Among the many subjects treated may be mentioned the receiver, transmitter, induction coil, primary battery, calling apparatus, hook switch and circuits of the telephone, telephone relay, self induction, capacity, telephone lines, switchboards, drops, transfer systems, common battery systems, house systems, protective devices, distributing boards, party lines, telephone wire, pole-line construction, overhead cable construction, underground cable construction, etc.

EMPLOYMENT DEPARTMENT—(Continued)

POSITION WANTED—Young man of twenty, having had some experience in electrical work, desires position as assistant electrician. Least salary accepted, $2.50 per day. Locality immaterial. Address *The Technical World*, No. 129.

WANTED—Position as Master Mechanic or Chief Engineer, by an experienced man. Least salary accepted, $1,250 per year. State of Massachusetts preferred. Address *The Technical World*, No. 122.

WANTED—Position as assistant to electrical engineer by an experienced man of thirty-eight. References furnished. Address *The Technical World*, No. 123.

WANTED—Position as instructor in Manual Training by an experienced man. Least salary accepted, $1,300 per year. New England preferred. Address *The Technical World*, No. 124.

WANTED—Position by young man (22) as trouble man, inside wiring or similar work in town of 10,000 or more. Three years' experience as lineman, wireman, trouble man, and care of alternating-current motors. References furnished. Address *The Technical World*, No. 125.

Stationary Engineer. Position wanted by a Dane, 40 years old, married, experienced in steam and gas fitting and metal pattern making. Salary, $2.50 per day. Address *The Technical World*, No. 141.

POSITION WANTED—as machine salesman, wholesale, by American 22 years of age, unmarried, with over 5 years' experience in machine shop work. Salary $50 a month. Address *The Technical World*, No. 134.

Tracer in drafting room. Position wanted by graduate of Chicago English High and Manual Training Schools. Had 3 years' course in Mechanical Drawing. Can draw, trace, and print well. Bohemian, 18 years old, unmarried. Salary, $6 a week. Address *The Technical World*, No. 152.

WANTED—Position in engineer's office (Civil Engineer preferred) by High School graduate without experience, 21 years of age, unmarried. Salary $40 per month. Address *The Technical World*, No. 135.

Machine and tool designer and draftsman. A married man 26 years of age, Swede, with 12 years' experience as a machinist and in tool work, desires position. Salary, $21 a week. Address *The Technical World*, No. 140.

Pattern Maker. A young unmarried man of 8 years' experience as a machinist, desires position as pattern maker. Salary, $12 a week. Address *The Technical World*, No 136.

WANTED—Position as Machine Shop Foreman by man experienced in machine-tool work, including planers, shapers, drills, wheel presses, milling machines, etc. Good references. Least salary accepted, $1,200 per year. Address *The Technical World*, No. 126.

Assistant electrician or switchboard tender. American, 18 years old, single, with six months' experience in wiring for motors, desires position. Address *The Technical World*, No. 139.

WANTED—Position by young man of 26 as Superintendent of Electric Light plant. Eight years' experience. Least salary accepted $100 per month. Address *The Technical World*, No. 127.

Tool maker and die maker. Position wanted by German with five years' experience as apprentice; 18 years old, single. Salary 15 cents per hour. Address *The Technical World*, No. 148.

Stationary Engineer. American of 14 years' experience desires position. Married, 37 years old. Salary $75 a month. Address *The Technical World*, No. 133.

FOR SALE—Complete long distance telephone, $5.95. Catalogue free. Climax Electric Works, New Salem, Mass.

Storage Battery Engineering. By Lamar Lyndon. 383 pages. New York: McGraw Publishing Co. Price, $3.00.

This book fills a place in storage-battery work which has perhaps never been adequately covered before—namely, that of a thoroughly practical book upon the details of the engineering applications of the storage battery adapted especially for the electrical engineer. The subject is treated to a great extent without mathematics; but where mathematics have been introduced the deductions can be easily followed on account of the clear treatment given. This book will assist the engineer in designing, installing, and maintaining battery equipments, as well as guiding him in the selection of the type of battery and auxiliary apparatus best adapted to the intended service, while the public in general can obtain a clear and concise idea of the advantages and disadvantages of the storage battery in actual practice. The more abstruse theories of the storage battery have not been taken up, as they are hardly within the scope of a work of this sort, which is intended as a practical guide rather than as a theoretical treatise.

The first part of the book deals with the storage battery, its construction, action under various conditions, and deterioration, and the causes of the observed phenomena. The treatment is almost entirely from a physical rather than a chemical standpoint. The second part of the book deals with the apparatus, devices, and methods used in the application and control of batteries. A description is given of the various systems of boosters, together with a discussion of each type. A specially valuable feature of the work is the illustration by practical examples of some of the most important systems.

Taken altogether this book forms a complete compendium for the engineer, in which any question that may arise in storage-battery practice, may be quickly and easily answered. The book is profusely illustrated with curves, cuts of commercial apparatus, diagrams, and typical installations.

Practical Pointers for Patentees. By F. A. Cresee, M. E. New York: Munn & Co. Price, $1 00.

In this small work is contained full information in regard to handling patents to obtain the best commercial results. Most inventors feel that when their patent is obtained, they have practically neared the end of their labors. As a matter of fact, it is usually the case that their work is just beginning. The author describes in detail just how to proceed to sell a patent to good advantage to the patentee, and also answers in an interesting manner such questions as how to arrive at the value of patents, what legal forms to use, etc., and gives statistics. This book is commended to anyone contemplating the placing of a patent on the market, and the small expense involved in its purchase will be saved many times over by following the advice given.

Mechanics, Molecular Physics, and Heat. A twelve weeks' college course. By Robert Andrews Millikan, Ph. D., Assistant Professor of Physics in the University of Chicago. 8vo. Cloth. 242 pages. Illustrated. Boston, Mass.: Ginn & Co. List price, $1.50; mailing price, $1.60.

This book combines the qualities of a class-room textbook and a laboratory manual. It aims to take the place of both, and thus to obviate the most common difficulty in the teaching of physics, that is, the lack of an intimate correlation between the class-room discussion and the laboratory exercises. Dr. Millikan has given laboratory work its true importance by building up his book about a number of well-chosen experiments. He insists on the thorough teaching of a few important facts rather than on the inadequate presentation of a great amount of material. Each chapter deals with some important law. First, the theory is stated; then follows the experiment; and finally there come a few problems based on the general principle involved.

The logical sequence of the various chapters is strongly emphasized. The book is a continuous course and not a group of unconnected experiments. Finally the author has insisted on the fact that physics is a science of exact measurements. The apparatus used has been selected with special reference to its ability to yield accurate results in the hands of the average student.

The Discovery of Induced Electric Currents. Vol. 1. Memoirs by Joseph Henry. 110 pages. Price, 75 cents. Vol. 2. Memoirs by Michael Faraday. 96 pages. Price, 75 cents. Scientific Memoirs Series; edited by J. S. Ames, Ph. D. New York, Chicago, Cincinnati: American Book Company.

Volume I contains sketches on the Production of Currents and Sparks of

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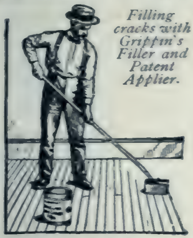
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Electricity from Magnetism; the Influence of a Spiral Conductor in Increasing the Intensity of Electricity from a Galvanic Arrangement of a Single Pair, etc.; Electro-dynamic Induction; Induction from Ordinary Electricity; and Oscillatory Discharge.

In Volume 2 are sketches on Induction of Electric Currents; the Evolution of Electricity from Magnetism; a New Electrical Condition of Matter; Arago's Magnetic Phenomena; Terrestrial Magneto-Electric Induction; Force and Direction of Magneto-Electric Induction Generally; the Induction of an Electric Current on Itself; Inductive Action of Currents in General; and the Relation of the Electric and Magnetic Forces, ending with a biographical sketch of Faraday.

These books are very interesting and instructive from the historical standpoint, as they recount the efforts of those great experimenters, Henry and Faraday, whose untiring zeal finally led to the most important discovery ever made in the electrical field—namely, that of Electro-magnetic Induction.

The Fundamental Laws of Electrolytic Conduction. Memoirs by Faraday, Hittorf, and F. Kohlrausch. Translated and edited by H. M. Goodwin, Ph. D. Pages 98. Harper's Scientific Memoirs Series. New York and London: Harper & Bros. Price, 75 cents.

This little volume contains sketches on Relation by Measure of Common and Voltaic Electricity and on Electro-Chemical Decomposition; a Biographical Sketch of Faraday; The Migration of Ions during Electrolysis; a Biographical Sketch of Hittorf; the Conductivity of Electrolytes Dissolved in Water in Relation to the Migration of their Components; and a Biographical Sketch of Kohlrausch. The contents will be found of much interest, as the book presents the papers on Electro-Chemistry which contain the original statement of the fundamental laws and experiments on which the modern theory of Electrolytic Conduction is based.

Diseases of a Gasoline Automobile, and How to Cure Them. By A. L. Dyke and G. P. Dorrise. Pages 232; 12mo. St. Louis, Mo.: Dyke Automobile Supply Company. Price, $1.50.

Perhaps there is no more interesting as well as valuable book published dealing with the different phases of a gasoline automobile, than this work issued by the Dyke Automobile Supply Company. From every point of view it is practical, and every page contains information of a nature that is sure to prove of service to the man who owns an automobile. A careful reading of this work will make a man to a large extent independent of repair shops. It should be carried in the tool-box of every automobile on every trip as an essential part of the equipment. All the different parts of the automobile are brought up for consideration—batteries, tires, gears, all receive attention. The drawings are good, the language is simple and well expressed. We prophesy for this work a large sale.

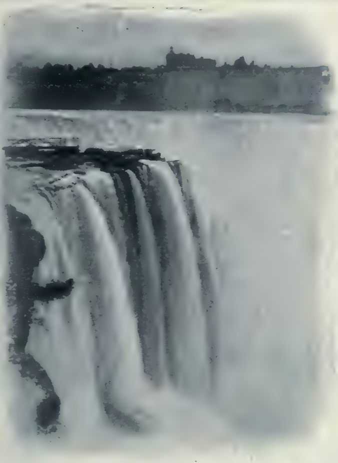
Machine Shop Arithmetic. By Fred H. Colvin and Walter Lee Cheney. Pages 131. New York: The Derry-Collard Company.

"Machine Shop Arithmetic" is the title of a small "Pocket Book containing some of the problems of every-day shop happenings." This book is written in a very clear and concise manner. It is adapted to the busy machinist who has not time to read an elaborate treatise. It is practical, dealing with problems constantly occurring in the machine shop—such, for example, as those involving screw-cutting, gears, threads, bolts and nuts, speeds of milling cutters, drills, taps, etc.

The part devoted to arithmetic is very practical and easily understood. The theory of square and cube root is explained better than in most regular textbooks. The numerous tables, such as those for cutting speed, bolt tables, metric tables, etc., add to the value of the book, as they are used constantly.

Air-Brake Catechism. By R. H. Blackall, Air-Brake Instructor and Inspector with Westinghouse Air-Brake Co. Pages 300. New York: Norman W. Henley Co. Price, $2.00.

The eighteenth edition of this book has been received from the press. It is in the usual catechism form of questions and answers, so well adapted for those desiring brief, explicit information. The first chapters deal with the Plain Triple, Quick-Action Triple, Troubles of the Triple, Freight Equipment, Slack Adjuster, Retaining Valve, Train-Line Governor, and other devices. Additional features are chapters on the Water Brake, Whistle, Signal, High-Speed Brake, and Recording Gauges. The practical infor-



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By HERBERT W. PEARSON
Detroit Engineering Society

Journal of the Association of Engineering Societies, :: ::
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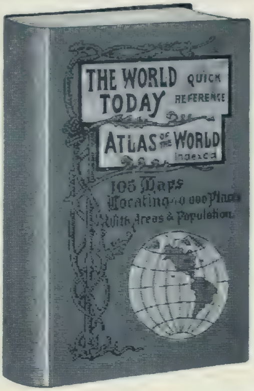

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mation on train inspection and handling should be of great value to those who handle the air brake and who must remedy various troubles. Leverage problems are well explained with numerous diagrams and examples. In addition to the several folded plates in the book, the publishers furnish two large colored plates, one of which shows the standard equipment for freight engines, and the other the equipment for passenger engines and cars, including the signal equipment.

Elements of Chemistry. A short elementary treatise for beginners. By Rufus P. Williams, author of "Introduction to Chemical Science," "Laboratory Manual of Inorganic Chemistry." etc. Pages 400; 12mo. Boston: Ginn & Company. Price, $1.10.

The aim of this book is to make the science of Chemistry so simple that the beginner will not become discouraged before mastering the underlying principles. Although elementary, it is free from the "popular style" and is in reality a school textbook. The chapter on Valence is exceptionally good, the elements being represented by cubes and the valence by hooks. Carefully selected exercises enable the student to test his knowledge from time to time. The book gives directions for about 350 graded experiments.

General Data on Thomson Recording Wattmeters. Schenectady, N. Y.: General Electric Company.

This book of 217 pages treats, as its name indicates, of the Thomson recording wattmeter. It is well arranged, and contains much valuable information upon this much used apparatus. Cuts are given of the different forms of recording wattmeter; and this is followed by a discussion of the instruments themselves, containing full instruction in regard to their construction and operation, explaining how they should be installed, the proper care to be given, methods of testing, reading, etc. Then follow tables of the constants and ratio of gears, comparative speeds of meters, armature data, etc. Next comes a section on dimensions consisting of tables and detail sketches. A very valuable section of the book is that devoted, with the very clear diagrams, to the connections of all the different types of meters upon the market.

CATALOGUES RECEIVED

American School of Household Economics. 3311 Armour Ave., Chicago, Ill.

The very attractive announcement of the American School of Household Economics is at hand. This outlines a distinctively new branch of correspondence education. Apparently the aim is to accomplish for women in the home something of the same good that correspondence study accomplishes for the engineer, the electrician, and the mechanic in the workshop. The "General Statement" brings out the fact that while the conditions in the home are vastly different from what they were two generations ago, yet housekeeping is governed by traditions that have come down from that time, and science has not thus far had the profound effect in modifying practices in the home that it has had in the workshop and the factory. Attention is called to the regrettable fact that most women have had no special training for their life work—"that of home-making."

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The list of the teachers and authorities who have prepared the lesson papers for the courses gives assurance of a high standard of work. Among these are: Mrs. Alice P. Norton, Associate Professor Home Economics, College of Education, University of Chicago; Miss S. Maria Elliott, Instructor in Household Economics, Simmons College, Boston; Dr. Alfred C. Cotton, Associate Professor Diseases of Children, Rush Medical College; Miss Isabel Bevier, Professor of Household Science, University of Illi-

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The Advisory Council includes the following prominent women: Mrs. Ellen M. Henrotin, Hon. President General Federation of Woman's Clubs; Mrs. Frederick W. Schoff, President National Congress of Mothers; Mrs. Arthur Courtenay Neville, Chairman Household Economics Committee General Federation of Woman's Clubs; Mrs. Linda Hull Larned, Past President National Household Economics Association; Mrs. Walter McNab Miller, Chairman Household Economics Committee of Federated Woman's Clubs of the State of Missouri; and Mrs. Mary Hinman Abel, Coworker in the "New England Kitchen" and the "Rumford Food Laboratory."

A full, illustrated synopsis of each subject makes very suggestive and interesting reading, and the whole pamphlet gives evidence of the serious purpose and practical usefulness of the courses.

The Director of the new School is Mr. M. LeBosquet, formerly of the staff of the American School of Correspondence, and the offices are located at 3311 Armour Avenue, Chicago.

Frick Company, Waynesboro, Pa. Pages 176.
Paper. 6 by 9 inches.

Catalogue on Refrigerating Machinery, issued as a Twentieth Century Greeting. The valuable chapters on mechanical refrigeration (ammonia compression system) make this book as much a textbook as a trade catalogue. The chapter entitled "Theory and Practice of the Mechanical Production of Cold" gives a good idea of the process and the functions of the various parts of the system. Following the detailed descriptions of the company's products are chapters on the following subjects: Refrigeration in Breweries and Packing Houses; Ice Making and the Machinery of the Ice Factory; and Distilling and Purifying Water. The chapter on Ammonia includes directions for tests, tables of properties, etc.

Houston, Stanwood & Gamble, Cleveland, Ohio.
Pages 24. Paper. 8 by 11 inches.

Engine catalogue illustrating special features of slide-valve engines. The slide valve is partially balanced by a cylindrical plug enclosed by a packing ring, which is pressed against the steam-chest cover by springs. In addition to engines of from 15 to 600 horse-power, this company builds hoisting engines, detached and semi-fixed outfits, and heaters.

Pittsburg Meter Company, East Pittsburg, Pa.
Pages 48. Paper. 6 by 9 inches.

Illustrated catalogue of Keystone water meters. The utility of the water meter forms the subject of the first pages. Following this is a detailed description of this form of meter. The half-tone work is excellent, as is also the press-work. The cover, printed in gold, green, black, and light blue, is exceedingly attractive.

Henry Vogt Machine Company, Louisville, Ky.
Pages 70. Paper. 6 by 9 inches.

Catalogue of Ice and Refrigerating Machinery (absorption system). This catalogue includes chapters on the principles of the absorption system, description of machines, manufacture of ice, insulation, etc.

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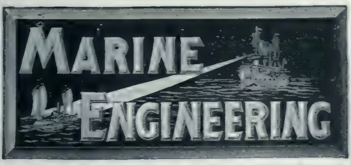

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Kroeschell Bros. Ice Machine Company, Chicago, Ill. Pages 84. Paper. 6 by 9 inches.

Catalogue describing Mechanical Refrigeration (carbonic anhydride system). In this catalogue the underlying principles of this system are explained with the diagram of the cycle of operation. The details of the machinery are explained and illustrated, together with such systems as the Direct-Expansion System, Brine System, Cold-Air Circulation, etc. As usual in such catalogues, the manufacture of ice receives due attention.

Cooper-Hewitt Company, New York.

A catalogue of 28 pages describing the recent development in the field of electric lighting, known as the Hewitt Mercury Vapor Lamp. In it are treated the principles and construction of the lamp, its efficiency, the color and quality of the light, its applications (among which particular mention is made of its application to photographic processes), and its economy. Directions are given for starting the lamp, both by the use of the high-potential spark and by the method of tilting. A handsomely prepared and interesting pamphlet.

MAGAZINES

The Engineer.

A description of the instruction given in Steam Engineering at Tuskegee (Alabama) Institute forms the leading article in the March 1st number of *The Engineer.* The students in this school certainly get practical experience, as no paid firemen or engineers are employed, the students running the machinery from nine to twenty hours per day. They start as coal passers and work up to be first engineer. The article is a most interesting one on the work of the school founded by Booker T. Washington, the famous leader of the colored race. We note that the electrical equipment is in charge of Mr. Charles W. Pierce, a graduate of Armour Institute of Technology and a student in the American School of Correspondence.

The article on Variable Speed Control discusses a very important and live topic, reviewing the attempts made before the present degree of success was attained. An instructive feature of this article is the classification of service according to the different requirements as regards range of speed, constancy of speed for any given position of the controller, constancy of torque, etc. Examples are also given of the different classes of work demanding such requirements. The particularly difficult problems offered by planers are explained. Next, the factors upon which the speed of a motor depend are taken up, and the advantages and disadvantages of methods of variation of speed by variation of applied E. M. F. and of field strength are considered. The article is to be continued.

In the number for December 15 last, a list of 32 examination questions was given. The answers to these questions are found in the present number. Those intending to take license examinations would do well to preserve these questions and answers as a check on their work.

Other noteworthy articles in this number are:

Using Exhaust Steam.
Combustion Engines.
Gas Power for Central Stations.

Power.

The March number of *Power* contains articles on the old and the new. The description of the old Newcomen engine built in 1810 follows a lengthy report of an efficiency test of the 1,250-K. W. steam turbine built for the Interborough Rapid Transit Company, New York City. The results of this test should be preserved by those interested in the subject, as reliable figures along this line are not often available.

The article on Lubricating Oils and Their Properties — How to Test Them and Detect Adulterations, is a great disappointment. The title leads one to look for the methods of testing oils and detecting adulterations. All that is given on this important subject is a fair description of the common forms of hydrometer. The "flash test," "viscosity test," "cold test," etc., have no description or explanation. The article ends abruptly, before it is half finished.

The practical letters are as usual filled with concise, valuable information, and in many cases are well illustrated.

Other articles are:

Burning Powdered Coal.
Division of Work in the Boiler Plant.
Further Details of the Cockerill Gas Engine.
Cost Chart for Steam and Gas Power Plants.

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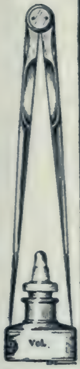

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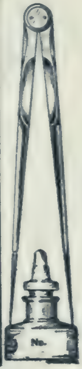

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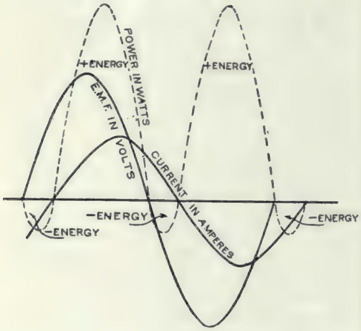
CONSULTING DEPARTMENT

Alternating-Current Circuit

Question: In an alternating-current circuit containing inductance, why does not the product of the voltage and current give the true power?—*E. A. C.*

Answer: In order that power shall be transmitted and work done on the external circuit by the alternator, the current and E. M. F. must both act in the same direction simultaneously. When self-induction is present, the current and E. M. F. are acting in opposite directions during part of each cycle, and during this period the line is acting as a generator and tending to run the generator as a motor; hence, power is returned to the generator, helping to run it. This returned power, as well as the expended power, is measured by the voltmeter and ammeter; hence they do not indicate the true power expended in work in the external circuit. The latter is indicated by the wattmeter because it shows the difference between the total power and that which is returned to the system.

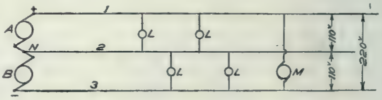


These conditions are represented graphically in the above diagram, in which is shown the curve of E. M. F. and the curve of current lagging behind it. The power curve, also shown, is positive during the part of the cycle when the E. M. F. and current act together, and negative when they are opposed. The algebraic sum of the power represented by the portion of the power curve above the line and that below, will give the true power expended in work in the external circuit as read by the wattmeter.

The Three-Wire System

Question: Kindly explain the Three-Wire System.—*G. M.*

Answer: The three-wire system makes use of two constant-potential generators, usually of 110 volts, connected in series, as shown in the accompanying sketch. Line 1 is connected to the positive brush of generator A, and line 3 to the negative brush of generator B; while line 2, called the "neutral," is connected to the junction of the negative brush of A and the positive brush of B. This gives a voltage of 110 between 1 and 2 and between 2 and 3, and of 220 between 1 and 3.



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The great advantage of this system lies in the saving of copper for a given line loss in the transmission of a certain amount of power. As will be seen, the voltage is doubled, and hence the current is only one-half as great. The line loss I^2R will then be only one-fourth as great for a given resistance, or, for the same line loss, the resistance can be 4 times as great, so that only one-fourth of the copper will be required for the outside wires; and if the neutral wire is made of the same size as the outside, the total amount of copper will be three-eighths of that needed on a two-wire system operating under similar conditions.

Shunt Generator Run as Motor

Question: If a shunt generator be run as a motor, why is the direction of rotation the same as before?—*S. H. J.*

Answer: Because while the armature current is reversed, the field current is in the same direction as before. This can be seen from consideration of two diagrams (Figs. 1 and 2), in which 1 represents the generator, and 2 the motor, the arrow showing the direction of current. This being the case, the direction of motion must be the same, whether the machine is run as a generator or as a motor. A generator tends to rotate in the opposite direction to that in which it is being driven by the prime mover, with direction of current in field and armature as shown in Fig. 1; hence, if the direction of armature current be reversed, but not that in the field, the machine will now run as a motor in the same direction as that in which it was being driven as a generator.

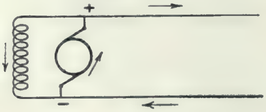


Fig. 1.

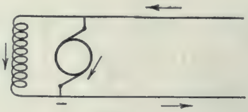


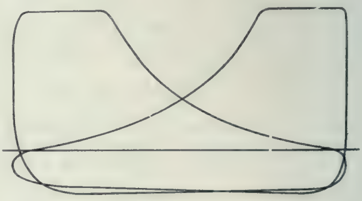
Fig. 2.

Calculating Horse-Power of Engine

Question: I send you indicator cards taken from a large marine beam engine. The dimensions, etc., are as follows:

Diameter of cylinder	62 inches.
Stroke	12 feet.
Revolutions	15½.
Scale of spring	20.

What is the horse-power of the engine?—*G. W. C.*



Answer: We have measured the indicator cards and found the mean effective pressure of each end in the usual way, by dividing the area by the length, and then multiplying the mean ordinate thus found by the scale of spring. As you did not give the size of the piston-rod, we have made no allowance for it. We find the average mean effective pressure to be 26.45 pounds; and by using the common formula for horse-power, we get the following:

$$\text{H. P.} = \frac{P \times L \times A \times N}{33{,}000}$$

$$= \frac{26.45 \times 12 \times 3{,}019 \times 31}{33{,}000}$$

$$= 900.$$

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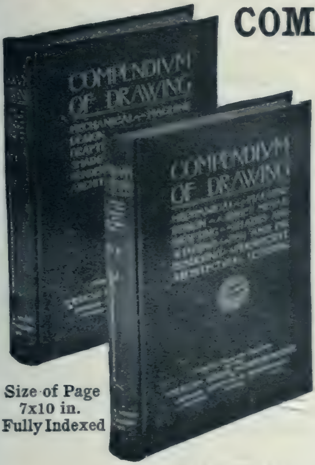

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Shearing Strength of Screw Threads

Question: In studying Machine Design I find that in calculating the strength of bolts, the tensile strength only of the bolt is considered. Kindly explain why the shearing strength of the threads is not taken into account.—*J. C.*

Answer: The shearing strength of screw threads is not taken into account in calculating their strength because the bolt is not likely to fail in this manner. If the threads are to be stripped by shearing, since the nut and bolt are made of materials which are practically of equal shearing strength, it follows that in order to shear, the threads of both nut and bolt must fail. This would, therefore, take place at one-half the depth of the thread. If this is the case, it follows that the area in shear will be one-half the cylindrical circumference on the inside of the nut.

The area of the surface of a cylinder is equal to its circumference multiplied by the height. If the diameter of the bolt at one-half the height of the thread is d, and the length of the nut is h, the area to be sheared is equal to $\frac{1}{2} \times 3.1416\, d \times h$. The length of the standard nut is made equal to the diameter of the bolt, and therefore the area to be sheared can be written $\frac{1}{2} \times 3.1416 \times d \times d$. We know that the load which will cause any object to fail can be calculated by the formula, Load=Area×Stress. The shearing strength of wrought iron is about 8,000 pounds per square inch. Therefore, the load which will cause the threads to shear equals $\frac{1}{2} \times 3.1416 \times d \times d \times 8{,}000 = 12{,}566.4\, d^2$ pounds.

Another way in which the bolt might fail is in tension; since the bolt is weakest at the bottom of the thread, this section should be considered in calculating its strength. The bolt is circular in section, and therefore the area at the bottom of the thread equals $.7854\, d^2$, if d is the diameter at the bottom of the thread. Again using the above formula, Load=Area×Stress, and knowing that the tensile strength of wrought iron is 10,000 pounds, we get: Load$=.7854\, d^2 \times 10{,}000 = 7{,}854\, d^2$ pounds. By referring to the load which is necessary to cause the threads to shear, you will see that this force is more than 1½ times as great as the force necessary to cause the bolt to fail in tension, without even considering the fact that the value of d in the last case is also somewhat smaller than in the former.

Number of Teeth in Gears

Question: Can you give an easy practical method of calculating the change gears to be used in screw cutting? Our lathes have tables attached, giving the gears necessary for ordinary threads, but I would like to know how to figure the number of teeth in the gears for cutting any thread whatever.—*M. J. M.*

Answer: For any lathe that has an attached plate giving the change gears necessary for different threads, but does not give the gears necessary for the special thread you wish to cut, proceed as follows:

Refer to this plate or table and find the number of threads which the lathe will cut when even gears are used, that is, when both change gears have the same number of teeth. Let us suppose that in this case you find that the lathe will cut 9 threads under these conditions, and that you wish to cut 17 threads on the screw. Then using the well-known formula we get:

$$\frac{\text{Number of teeth in gear on stud}}{\text{Number of teeth in gear on lead screw}} = \frac{9}{17}$$

Therefore, if we use a gear with 9 teeth on the stud, and one with 17 on the screw, we can cut 17 threads per inch; or as long as the numbers of teeth have this ratio, we can use any gears to cut the required number of threads. For example, we can use any set of gears with this ratio, as 9—17, 18—34, 27—51, etc.

For the Student In Engineering

CASSIER'S MAGAZINE
March, 1904

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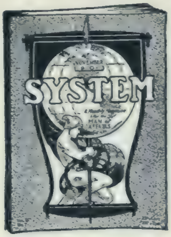

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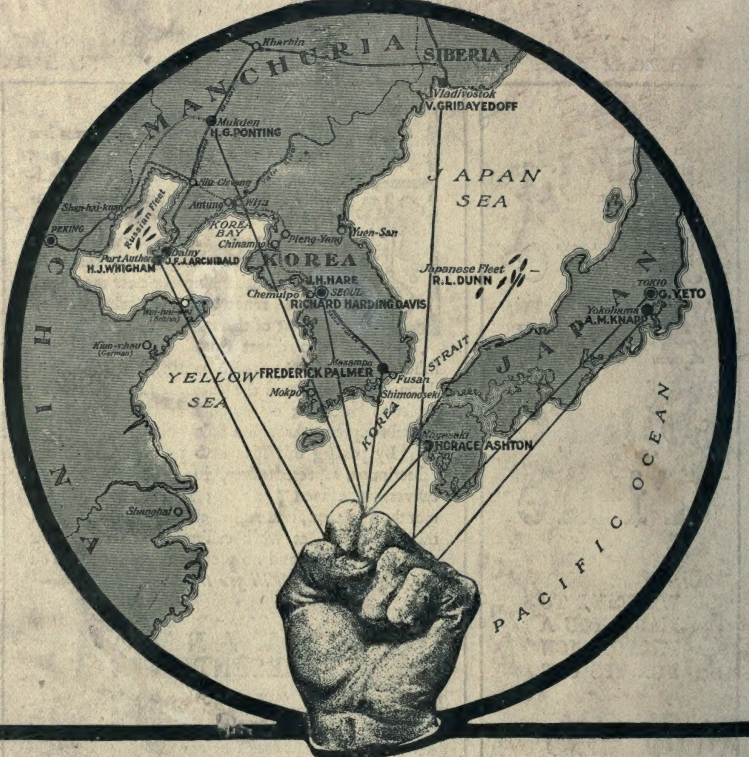

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